POWER

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Purposeful Anecdotes

Some Results of Mismanagement

AN inefficient manager, newly appointed over a number of power plants in office buildings, notified the chief engineers that he wanted them to work with their hands while he would do the "head work" and assume responsibility for the operation. All remonstrance from the chiefs he ignored.

Each plant employed a number of permanent handy-men to do part of the plumbing, other work, and repairs. Although these men were not journeyman mechanics, they worked successfully under the instruction and supervision of the chiefs — up to the beginning of the new manager's administration.

This manager made one inspection at each plant every day and was delighted to find the chiefs had taken him at his word and were working in overalls with the men. At one plant the chief was covering steam pipes, at another he was putting in a cast-iron soil pipe; at every plant he found the chief doing the work which formerly he only directed. To the manager everything appeared to be going well. There was a reduction in the bills from outside companies for plumbing and other work, which pleased the manager.

Some time passed under these (to the manager) satisfactory conditions, when he learned that his predecessor had always received daily reports from each chief, giving itemized information about the operating and other costs and on the general condition of the plant. Upon questioning the chiefs, they advised that it was impossible for them to supply him with those data, as they were working every day and all day; therefore outside of himself no one had been attending to these things. But the chiefs volunteered the information that, owing to the little overseeing they found time to do, the plants were deteriorating rapidly, as no one had been directing and instructing the men how to do the work properly.

It was during one of these conversations that a message arrived for the manager. It informed him that in one plant the fireman had gone to sleep leaving the feed pump running, and the water had gone over to the engine, causing a wreck. Soon another messenger arrived, and informed the manager that he was wanted at another plant, as the engine was at a standstill on account of damage caused by hot bearings. A company investigation followed, and the manager was discharged. The engineers, who had put their protest to the manager in writing and kept copies, were exonerated from any blame.

It is not safe to bluff in engineering; the bluff will be called.

Contributed by JAMES E. NOBLE, Toronto, Ont., Can.

The Passing of Harrison Street Station, Chicago

By A. Bement

SYNOPSIS—In less than three months' time this notable station was dismantled. The copper and brass were first saved, and the equipment, which for the most part was as good as new but obsolete, was cut up by oxyacetylene torches and sold as scrap.

During the past few months the Harrison Street Station of the Commonwealth-Edison Co. has been torn down. When everything is considered, it was probably the most important electric station in the world, and it had become known as the laboratory of the central-station industry. It was built by the Chicago Edison Co. during the time of the World's Columbian Exposition and went into service in 1894. At the time it was designed, the standard electric generator station for the Edison three-wire system consisted of high-speed engines of from 100 to 200 hp. each, located on a lower floor, driving bipolar generators on the floor above by means of belts.

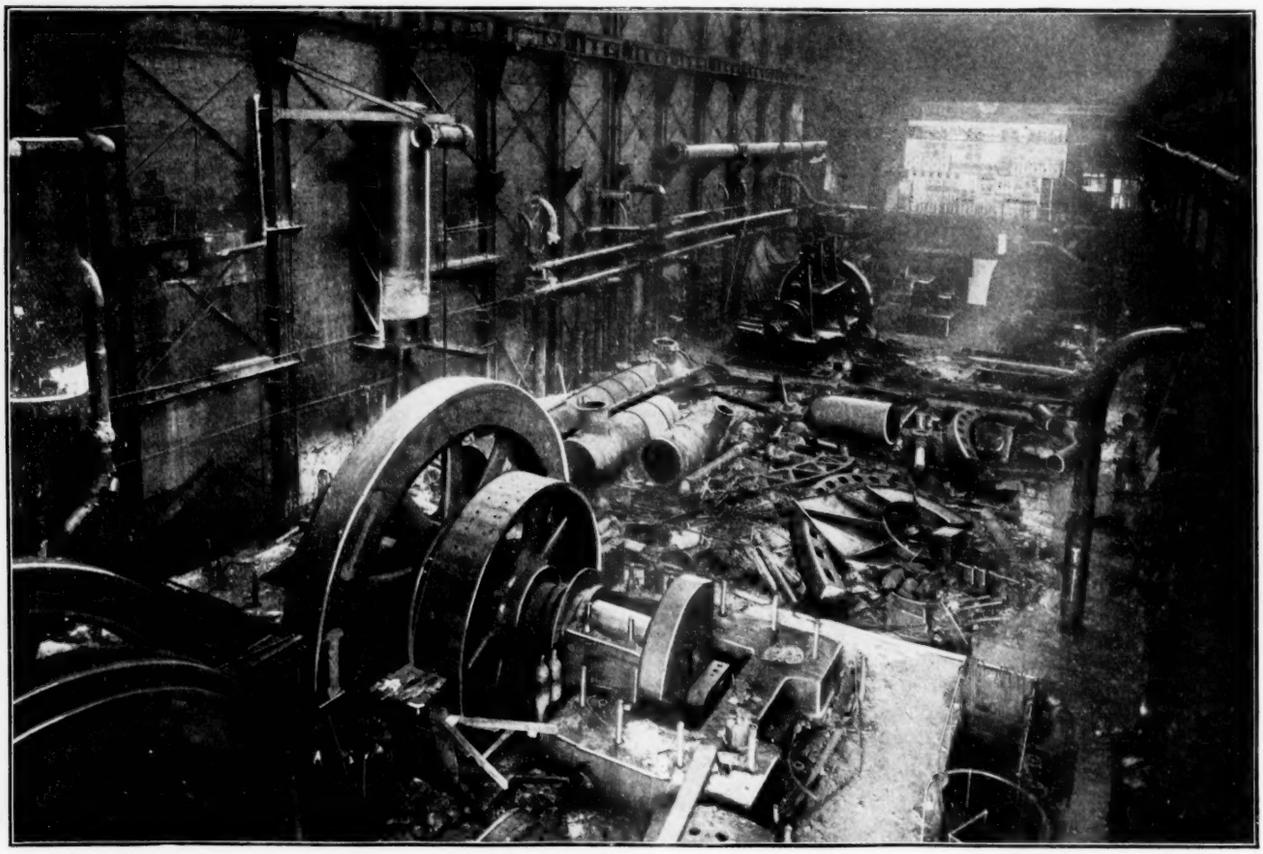


FIG. 1. VIEW IN ENGINE ROOM LOOKING TOWARD SWITCHBOARD

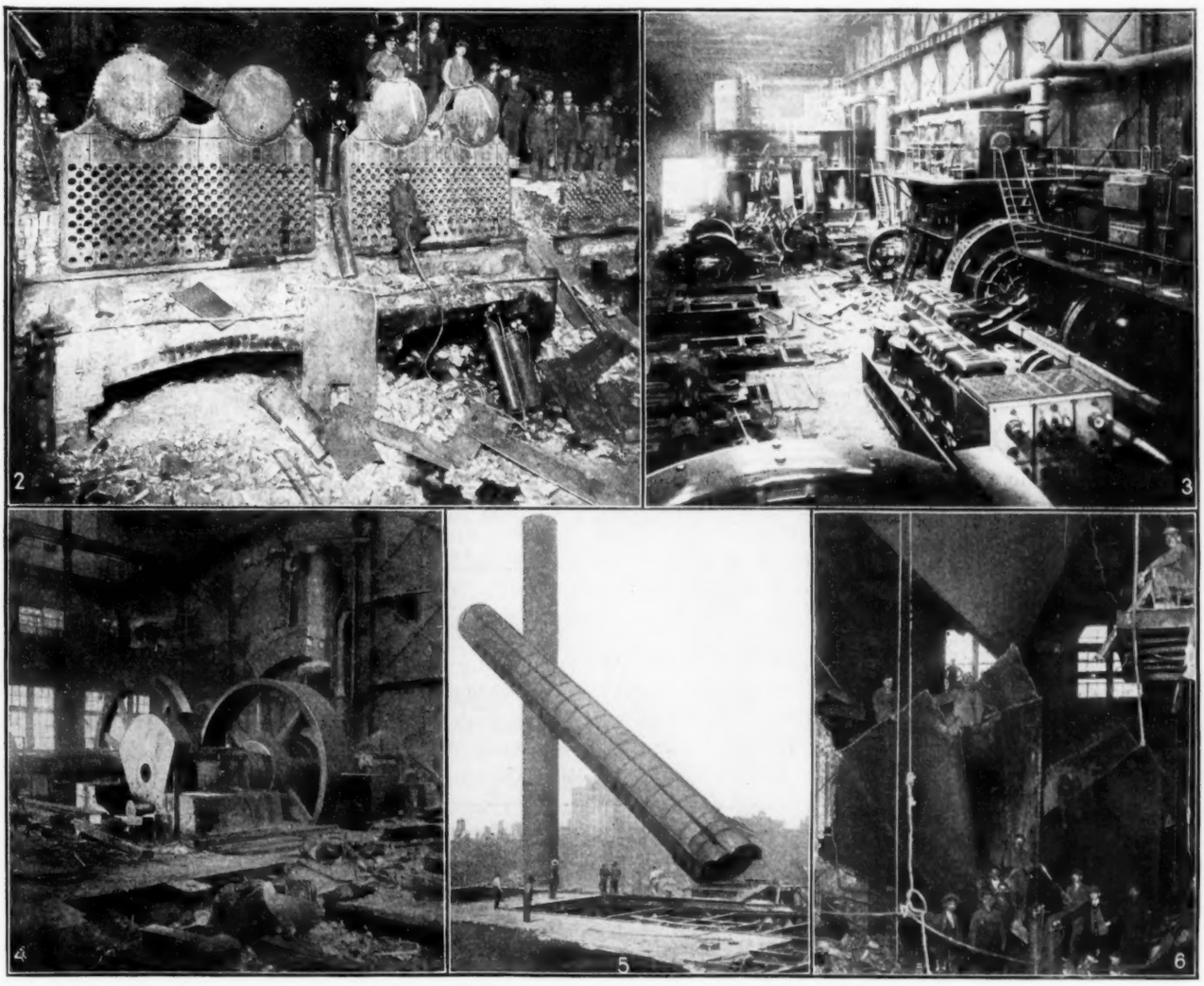
These stations were always located in a densely built-up neighborhood near the business center of the city, so that they could be as near the customer as possible, because the cost of the heavy copper transmission lines required with the low-tension direct current then distributed was great and the line loss made it impractical to cover anything but a small territory. Under such conditions coal and ashes had to be hauled in wagons, because there could be no railway tracks in the location then considered necessary for a station. The engines were noncondensing, discharging the exhaust steam to the atmosphere because no condensing water was available.

Notwithstanding the disadvantages, the importance of a location at or near the center of the load was so great that it was generally considered to be out of the question to place a station on the railway or where condensing water was available. When the location at the river and Harrison St. was selected, many of the wise men in the electric business seriously questioned the wisdom of the venture (notwithstanding the site had abundant condensing water and was on a good railroad) because of its being so far from the center of the load.

Harrison Street Station was not following precedents; if it had been, it would not have become a notable station. Just before the plant was designed, a new president had come to the company—Samuel Insull, a man who could see into the future—and "Harrison Street" was the result. That he made a good guess is shown by the fact that the maximum load of the system in 1894 was about

6,000 kw. and in 1915, 338,000 kw. The original plans for the equipment consisted of twelve engines of from 600 to 1,200 hp. each, although two of the units were never installed because the growth of the business demonstrated that they were too small.

The new station was larger and much more complicated than those with which operatives were familiar. The result was that the troubles, quite prevalent in the electric



FIGS. 2 TO 6. SHOWING DISMANTLING OPERATIONS IN HARRISON STREET STATION

Fig. 2—Cutting up water-tube boilers. Fig. 3—Two of the large vertical units in background. Fig. 4—Crankshafts and partly dismantled flywheels of two large units. Fig. 5—Wrecking one of the 12x125-ft. steel stacks. Fig. 6—Cutting away the coal bunkers.

generating business of those days, were in proportion to the size and complication of the plant. For this reason the history of the first year was one of many difficulties. At this point, however, W. L. Abbott came on the job. Under his direction as operating engineer, order came out of confusion and the station established a record for operating economy and efficiency.

In connection with the operating methods many researches and experiments were conducted in a study of combustion, in devising methods for the management of boiler fires, and in the study of coal—its values, characteristics and peculiarities. It was in this station that the requirements for smokeless combustion of bituminous coal were definitely worked out and put in practice on a large scale, with the result that the station became known the world over for this accomplishment and the method was extensively adopted by others. Experiments to determine the heat-absorbing efficiency of boilers were made, and means for the application of the results were devised which were copied and used extensively by boiler manufacturers.

When alternating current first attracted attention, Louis A. Ferguson, the vice-president of the company, saw at once its advantages and the opportunity it afforded for a more efficient and economical means of distributing electricity. He then began the development of a scheme for the distribution of alternating current which has grown to be universal and which has greatly increased the availability of electric supply. The first installation was in sending current to one of the old generating stations at Twenty-seventh St. and Wabash Ave. The success of the venture was so great that its application was extended, with the result that the business grew so fast that additional power was placed in the station, until about 1900 to 1901, when it had reached its capacity. The original direct-current equipment was of about 6,000 kw. capacity in ten engines. The new alternating-current capacity was about 11,000 kw. in four engines. In this

two or three years the rate of growth of the business was phenomenal, and the station, which less than ten years before seemed to many people so large that it could never, within a reasonable time, reach its capacity, was not only too small, but had become obsolete by the beginning of the great Fisk Street turbine station, and later by the Northwest Station with its enormous turbines.

In the later years, Harrison Street has been on the retired list, being used only occasionally. Now it has been demolished to give way to some railroad improvements in connection with a new freight and passenger terminal for the Pennsylvania and other roads. When the wrecking of the plant began, most of the engines were as good as they were when installed; some were better. It would naturally be expected that they could have been sold for use somewhere else, but they were broken up and sold for junk because there was no market.

Machines Broken or Cut Up

Never before has such a great quantity of large machinery of the kind been broken up. The method of doing it is not only interesting, but illustrates the adaptability of the oxyacetylene torch. It would have been possible, of course, to unscrew bolts and nuts, to drive out keys and in other ways take the machinery apart; to cut rivets in structural parts of the building, in coal bunkers and in other similar features of the plant. But this does not suit our modern-day wrecker—his method is destruction on a grand scale.

The copper and brass, on account of its greater value than iron or steel, had first attention. Iron valves were smashed in order to release the brass seats and gates. Electric generators were torn apart to get the copper; copper cables were placed in piles, and the insulation was burned off. The great switchboard, which occupied one end of the long main engine room, contained an immense amount of copper bars, material at the time of its wrecking that was costing 48c. per lb. at the mills. When the copper and brass had been recovered, destruction of the engines began. If it was easiest to unscrew bolts and nuts to separate parts, this was done; otherwise the oxyacetylene flame was used and the member was cut through.

The flame is very efficient in cutting; it works rapidly, making a narrow cut to any depth required. Fig. 1 is a view looking toward the switchboard end of the main engine room, showing the progress of the destruction. Fig. 3 is a view from the switchboard looking toward the two largest engines, one of which is back of the other and does not show.

Fig. 4 is a view of the crankshafts and partly dismantled flywheels of two of the largest engines. As shown, these wheels were made up in sections, the rims being held together by heavy links which were shrunk into receptacles in each end of the rim section. On the right will be seen one end of one of these links which has been cut in the center. The gas cylinders of the oxyacetylene equipment, furnished by the Imperial Brass Co., may also be seen. The 36-in. crankshafts were tough propositions, each being cut in three lengths. The foremost crankshaft with its generator and flywheel weighed over 400 tons.

Fig. 5 shows one of the 12-ft. steel stacks falling. Five in all served the station. They were supported by the steel frame of the building and rose 125 ft. above the roof. These stacks were cut at the base just above the roof and, by jacking on one side, were thrown over bodily, the time of the complete operation on each stack being less than two hours.

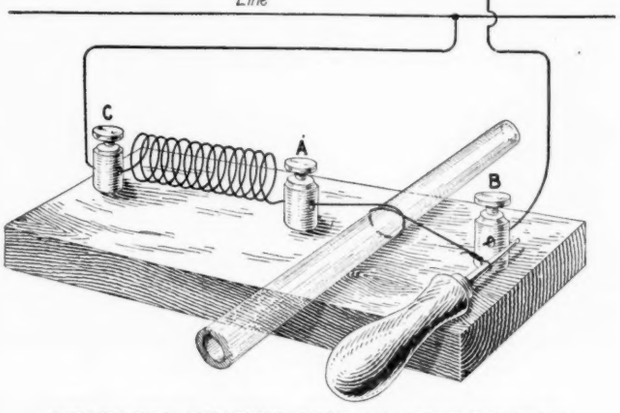
The main boiler room contained 24 large water-tube boilers. There is a fairly good market for boilers, but as these ranged from 400 to 500 hp., they were too large to be loaded on cars intact. For that reason principally most of the boilers could not be sold, but were cut up with the flame into pieces just the size for feeding into an openhearth steel furnace. The headers were cut apart as shown in Fig. 2 and forced outward by jacks falling into the pit and leaving the tubes behind. The main boiler room had overhead coal bunkers with a capacity of 1,200 tons. As shown in Fig. 6, these bunkers were cut loose from their fastening by the flame and allowed to fall to the floor below, where they were then cut up.

The only portion of the building that did not find its way to the junk pile is the principal part of the steel frame of the main engine room. This will be used in a new industrial building. One of the 600-hp. triple-expansion engines was presented to the University of Illinois to be exhibited in its engineering museum as a unit of obsolete type. Four of the boilers that were in the annex boiler room, owing to their sectional characteristics, were taken apart and three of them placed in storage for further use, while the fourth has been installed in a Chicago office building. The entire work of dismantling occupied less than three months.

Breaking Gage-Glass to Length

By L. V. Curran

The illustration shows a way of cutting or, more properly, breaking a gage-glass. A high-resistance wire, such as is used in domestic heating devices, is arranged between binding posts on a board, as shown. Connections to the line are made at *B* and *C*. The resistance wire is looped around the glass to be cut and connected to post *B* and



MEANS FOR HEATING TUBE AT POINT DESIRED

current turned on. Binding post *A* will allow adjustment for different sizes of tubes. After the wire has been red a few seconds, the glass is removed and plunged into water and a good clean break will result. The wire must be drawn tightly around the glass and must be slightly separated at what would be the meeting point of the loop, otherwise it will form a short-circuit and no current will flow through the loop. If the board is made portable and an attachment plug is used for the line connection, the rig can be used anywhere.

Locating Faults in Alternating-Current Induction Motors

SYNOPSIS—The troubles that are common to the induction motor are treated, also the methods of locating and repairing these faults.

In polyphase motors (two-phase or three-phase) of the squirrel-cage type, owing to absence of a commutator and an insulated winding on the rotor, the electrical troubles are practically confined to the stator winding and starting device. The troubles in the stator windings may be classed under six headings—namely, open circuits, short-circuits, grounds, heating of the windings, incorrect voltage and frequency.

Heating of the stator winding of a polyphase motor may be caused by overload, low voltage, low frequency, open circuit or a short-circuit in one or more of the stator coils. When a polyphase motor is running, if one phase is opened either by a fuse blowing or an opening in the stator windings, the machine will continue to operate as a single-phase machine. If the motor is carrying near its rated load, the single-phase will take a current much in excess of its rating, which will cause it to heat. A polyphase motor should be protected by some device that will disconnect the motor from the line in case one of the phases opens. The machine will not start if one of the phases is open in a two-phase or a gamma-connected three-phase machine. This condition will be indicated by the machine emitting a humming sound. If one phase is open in the winding of a three-phase delta-connected machine, it will start if not heavily loaded; but the starting torque will be reduced materially. If one of the phases is open in the external circuit, a polyphase motor will not start under any condition. When compensators are used, especially if they use a butt-type contact as shown in Fig. 1, quite frequently the circuit is opened by the contacts being burnt on the ends.

Open Circuits in the Stator Windings

The diagram, Fig. 2, represents the internal circuit of a two-phase motor and Fig. 3 the internal circuit of a three-phase gamma-connected motor. It is evident that the open shown at X in either figure can be indicated by disconnecting the machine from the line and testing with a lamp. The open shown at X in the three-phase delta-connected winding, Fig. 4, cannot be located by testing at the motor terminals, for if the test circuit is connected across terminals A and B current can flow through phases B and C in series and the testing device would indicate a closed circuit when winding A is open. Consequently, it will be necessary to open the connection between two of the phases before the open phase can be located.

In a great many cases the open occurs where the lead connects to the windings. If the defect is not here the open coil may be located by removing the insulation from the middle connection of the winding and connecting it to one terminal of the switch. With a lamp connected to the other terminal of the switch test first to one and then to the other terminal of the winding as indicated in Fig. 5. The defect will be indicated by the lamp not lighting. The insulation may now be removed from a connection in the center of the defective group of coils and each section in this group tested again. In this way the defective coil may easily be located. After it has been located and the defect cannot be found outside of the coil, the coil may be dropped out of circuit as shown at 14. It will be seen that the terminals of coils 13 and 15 that connected to coil 14 have been disconnected from this coil and connected together, thus leaving coil 14 out of the circuit.

The torque of an induction motor varies as the square of the voltage at its terminals; therefore, if the voltage is materially reduced at the motor terminals when it is carrying near its rated load, the increased current may

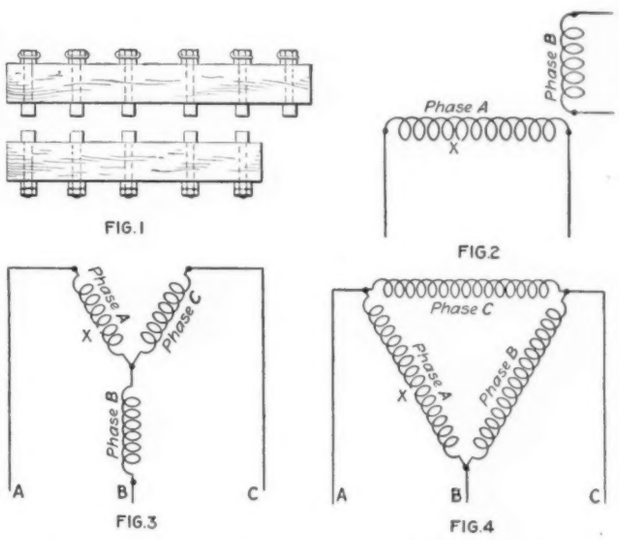


FIG. 1 FIG. 2 FIG. 3 FIG. 4

FIGS. 1 TO 4. REPRESENT PARTS OF POLYPHASE MOTORS AND STARTERS

Fig. 1—Butt-type contacts for induction-motor starting compensator. Figs. 2, 3 and 4.—Schematic diagrams of induction-motor stator windings

be enough to cause excessive heating. The remedy for this would be to correct the voltage. If the feeders are long the trouble may be caused by too great a drop in the line; under this circumstance it would be a case of putting in larger line conductors.

Low frequency will cause a decrease in speed and may cause heating. This will have to be rectified at the power house, as the frequency is determined by the speed and the number of poles in the generator.

A short-circuit in the stator coils of an induction motor will cause heating, but not so serious as in a direct-current machine, and may run for quite a period before burning out. The defective coil may be located in a manner similar to that used to locate a short in a direct-current armature. A direct current is sent through the winding and a millivoltmeter, or ammeter without a shunt, is used to take the drop across each coil as shown in Fig. 6. A short-circuit is indicated by a reading lower than normal. If an alternating current of normal voltage is applied, a low-reading voltmeter is used. The scale range of the instrument should be about double the line voltage divided by the number of coils in series. Instead of removing the insulation from the connections between the coils,

the test lead from the instrument may be fitted with sharp-pointed terminals which can be used for piercing the insulation.

The defective coil can usually be located by connecting the machine to the line for a short period and then noting the comparative temperature with the hand, the faulty coil being much warmer than the others. A short-circuited coil is cut out in the same manner as an open coil (explained in Fig. 5) only the coil must be cut in two at one end to eliminate the short as shown at *X*, Fig. 6.

The short-circuit between phases may be located so as to cause heating, but in most cases the machine will fail to operate, usually blowing the fuses or opening the circuit-breaker. A short between phases in a two-phase motor may be determined by connecting one terminal of a test circuit to one terminal of one phase and the other terminal of the test circuit to one terminal of the other phase. A short would be indicated by the lamp lighting. From an examination of Figs. 3 and 4 it will be seen that the stator windings of a three-phase motor are interconnected; therefore, before a test for short-circuits between phases can be made, it will be necessary to open the connections between the three different groups of windings.

A ground in the stator winding would have very much the same effect as a short between phases; therefore, in case of trouble on an induction motor, grounds should be one of the first things to look for.

Bearings worn so as to allow the rotor to rub on the stator core will cause heating. This is usually accompanied by noisy operation of the motor and frequently the motor will fail to start. The air gap in induction motors is very small; therefore, a slight wearing of the bearings may have considerable effect upon the operation of the machine. In some cases the bearings are designed to allow centering the rotor in the air gap.

Squirrel-cage rotors as they are constructed today give very little trouble. In a great many cases the end rings are either welded to or cast on the bars; consequently, there is no chance of trouble arising from loose bars,

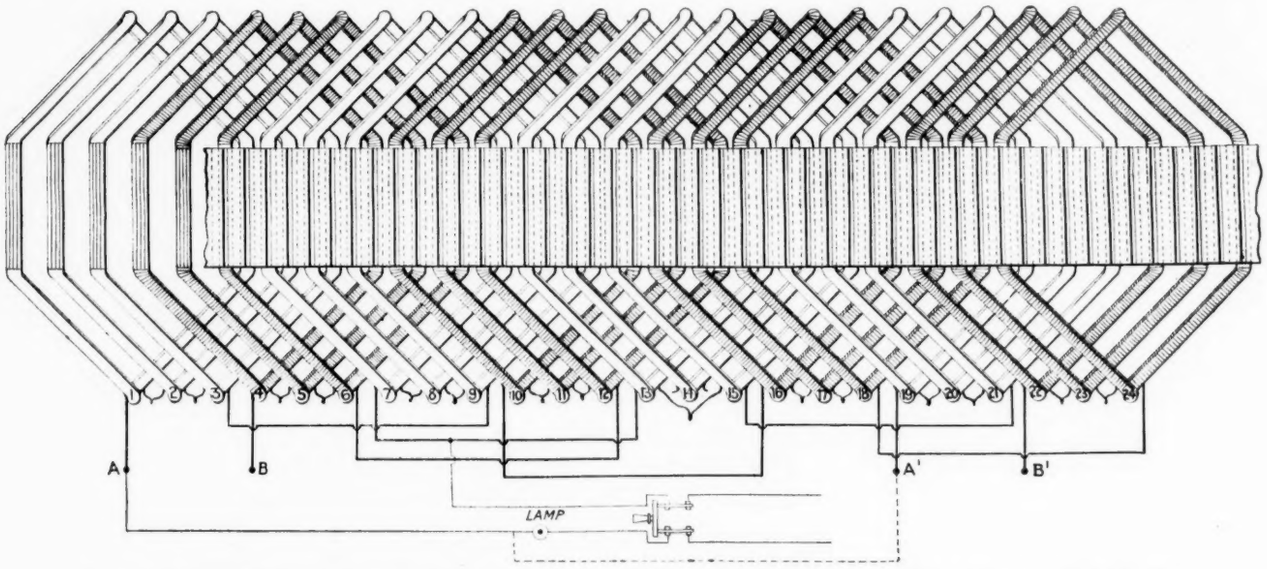


FIG. 5. SHOWS METHOD OF TESTING FOR AN OPEN COIL AND HOW TO CUT THE DEFECTIVE COIL OUT

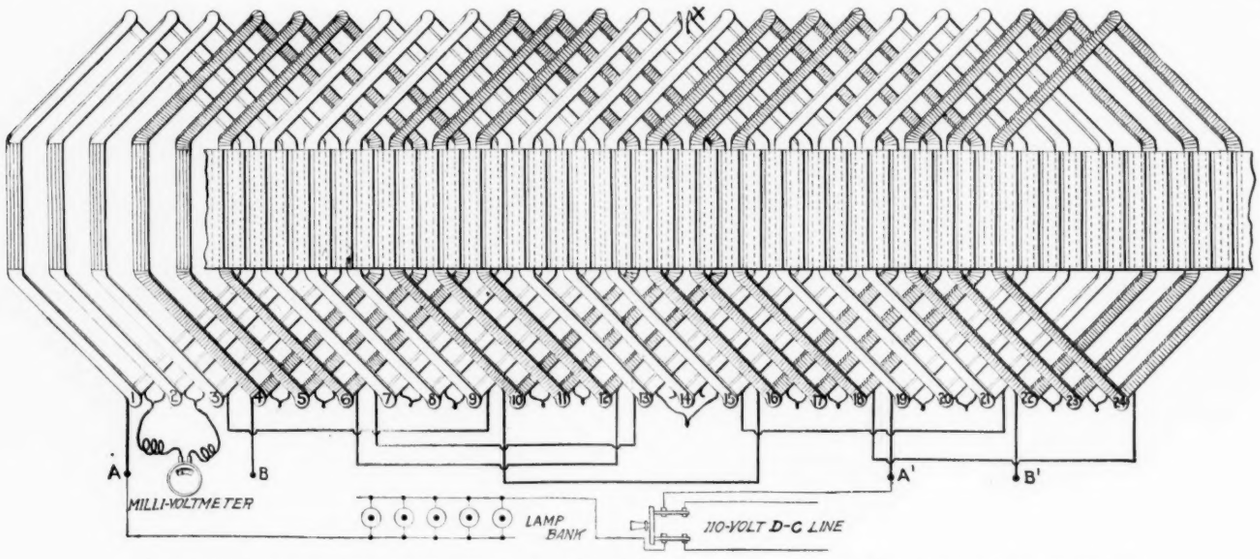


FIG. 6. SHOWS HOW TO TEST FOR A SHORT-CIRCUIT IN THE STATOR WINDING AND HOW TO REMEDY THE FAULT

which is about the only electrical trouble that may occur in this part of the machine. Poor connection between the rotor bars and end rings may cause noisy operation, poor starting torque or slow speed.

With the wound-rotor type several troubles may arise, such as brushes making poor contact or becoming stuck in the holder, slip rings worn and rough, short-circuits in the rotor winding, grounds in the rotor winding and open circuits in the rotor circuit. These troubles will cause one of two things—the motor will either fail to start or after it does start will vibrate as if the rotor were out of balance. One ground in the rotor will not have any effect upon the operation of the machine under any condition. In fact, some machines have one of the slip rings ground to the shaft and one terminal of the winding ground to the core. The rotor-winding defects may be located in the same way as those in the stator.

What has been said about stator troubles on polyphase motors applies equally well to single-phase machines. In the single-phase repulsion type an insulated winding is used on the rotor and any of the well-known remedies for armature troubles may be applied to it. Defects may be located by the same methods used for direct-current machines. On account of this machine possessing the speed characteristic of a direct-current series motor, some means must be provided for converting it into one having constant-speed characteristics. In general this is done in one of three ways—by short-circuiting the commutator after the machine comes up to speed, by using an additional set of brushes between the main or energy brushes, or by placing a squirrel-cage winding in the slot under the commutated winding. With the first two methods, which are the ones most commonly used, there is a possibility that the motor may race, either by the commutator not being properly short-circuited or by the brushes sticking in the holders. The remedy in either case is obvious. From what has been said it will be seen that the troubles in an induction motor are similar to those in a direct-current machine and are located in most cases in the same way.

Outdoor Metering Equipments

The supplying of service from high-tension transmission lines, where the expense of a substation is not warranted, has prompted the Westinghouse Electric and Manufacturing Co., of East Pittsburgh, Penn., to develop a line of metering equipments inclosed in weatherproof casings, of which the illustrations are typical. These outdoor metering equipments have been developed so far for 60-cycle polyphase service for current ratings not exceeding 200 amp. and for voltage ratings from 11,000 volts upward.

Each equipment consists, as shown in Fig. 1, of a standard polyphase watthour meter (the meter panel is shown at *M*), two current transformers, a polyphase voltage transformer *P*, and three choke coils *C*. The equipment is inclosed in a sheet-steel case with a cast-iron cover supporting three high-tension outdoor-type terminals, Fig. 2. The sheet-steel case is subdivided into two compartments, *A* and *B* as shown. The compartment *B* is filled with oil in which the transformers and choke coils are immersed, while *A* serves to inclose the meter

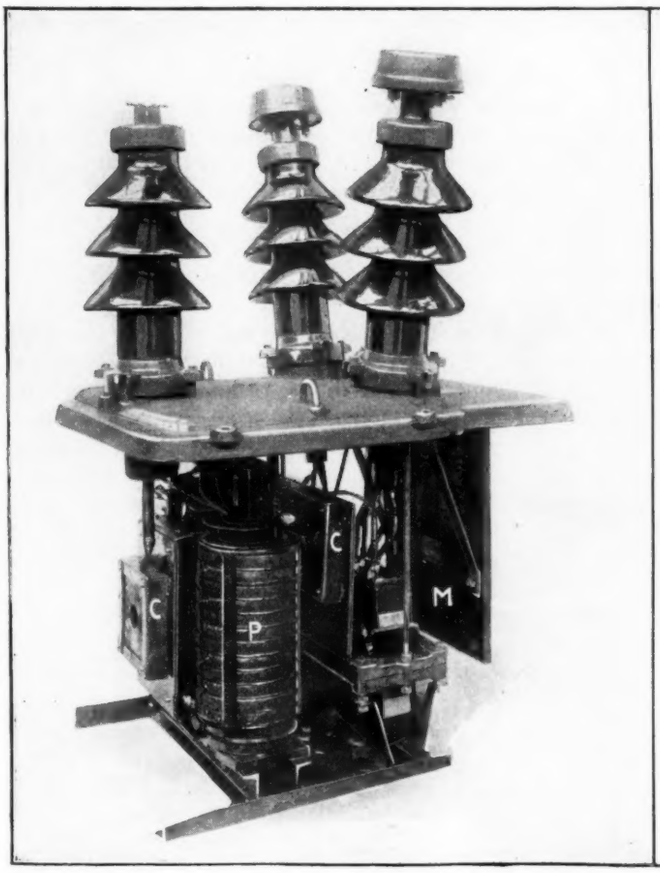


FIG. 1. METERING EQUIPMENT REMOVED FROM TANK

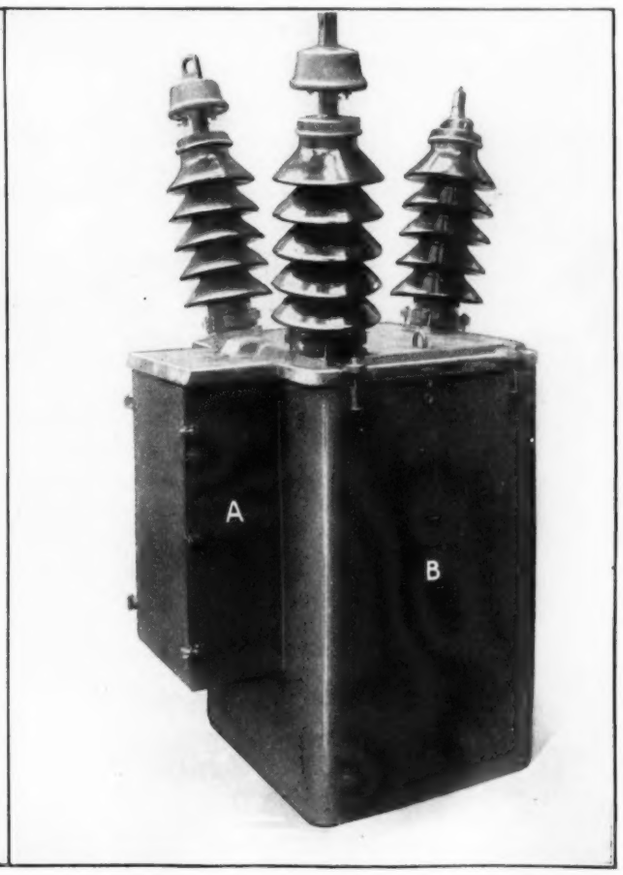


FIG. 2. METERING EQUIPMENT WITH TANK IN PLACE

and meter panel. On the meter panel are also mounted two fuses to protect the voltage circuit of the meter, and two calibrating links located in the current circuit. These calibrating links consist of fuse clips with a brass tube inserted instead of fuses. The meter may be read or checked upon opening the hinged door which covers the entire front of the meter compartment. The arrangement is such that the entire outfit, including the meter panel, can be raised out of the tank without disconnecting the meter leads.

Three primary outlet terminals provide the necessary primary connections, one of the terminals serving as the common connection of the voltage-transformer windings, while each of the other two terminals provides connection for one current transformer and one end of the voltage-transformer windings.

Each current transformer has two primary windings which may be connected in series or in parallel by connecting links in the weatherproof cap at the top of the outlet terminals. The polyphase voltage transformer consists of a three-phase core having windings on the two outer legs only, and is therefore equivalent to two single-phase voltage transformers connected in open delta.

Choke coils are inserted between the voltage-transformer windings and the outgoing leads, to protect the transformer windings against high-frequency disturbances.

Fuel-Economizer Pointers

By Frank Beers

Erecting economizers is no cinch, and repairing them in plants where they have been in use for fifteen years or so and where new tubes have to be put in is worse. It would be all right if, in the first place, plants were built with proper regard for the economizer, but sufficient space is rarely provided. Room and light at the side of the flue to inspect the scrapers and bottom headers, even after taking away the sectional covering or tearing down the brickwork, is practically unheard of. A stationary ladder to get to the top of the economizer in order to examine the safety valve, the top boxes, or headers as they are sometimes called, and the gearing mechanism is a hoped-for device of the future; and soot-chamber doors are about as accessible as the enemy's forts. As for the chiefs and operating men, there is no better body of men in any trade—bar none—and most of the older engineers know all about keeping an economizer in good working order; but many are put in where the economizer is new to the man in charge at the plant, and a few don'ts may be in order.

To get the best results in operating an economizer it seems that a little common sense is all that is required. An economizer is really a smoke-flue boiler, heating the water to about the boiling point in order to make it easier for the boilers to convert it into steam. It must, of course, be given some attention, but this amounts to little compared to the attention demanded by the boilers; still it must be done, and done regularly. Following are some of the points to be observed:

Economizer Don'ts

1. Don't start making repairs while the economizer is under pressure. None of the joints should be interfered with until the economizer is fully shut down. To do this open reserve flue damper, close inlet dampers, open boiler-feed valve, then close the economizer inlet and outlet feed valves.

2. When putting the economizer in service after cleaning or making repairs, don't put hot gases through it until you are sure you are feeding water through it into the boilers.

3. Don't allow the soot chamber below the economizer to get too nearly full. Some will accommodate more than others, but the soot should be cleaned out at least once a month. The space between the tubes, bottom headers and soot walls should also be thoroughly cleaned.

4. Don't forget to oil scraper-driving mechanism and gears regularly, but avoid letting grease get on the chains and chain wheels, or they will slip. When filling up the oil guards, be careful not to spill oil over the top header lids or caps, as the oil and dirt fills up and cakes into the holes in the top header caps, making it hard to replace them after cleaning out tubes.

5. Don't allow the scrapers to remain out of order. If they stick, remove the setscrew connecting the chain pulley and wormwheel and by means of the handle on the pulley spindle work the scrapers up and down until they run freely.

6. Don't let cold air get into the main flues. Make the brickwork air-tight. The damper in the reserve flue should fit tightly.

7. Don't forget that the draft of the boilers should be regulated by the main damper at the outlet end of the economizer and not by the boiler dampers.

8. Don't neglect the valves. They should be examined periodically, especially the safety valve. Any water waste from the latter should be delivered elsewhere and not into the soot pit, flues or cleaning-out spaces.

9. Don't feed water into the economizer at a temperature less than 90 deg. F. Colder water causes condensation on the lower portion of tubes and bottom headers, causing corrosion.

10. Don't let the economizer tubes get badly incrusted with scale. One of the greatest advantages of the economizer is that it precipitates a lot of the scale-forming ingredients in the water, which settle in the economizer as soft sludge which is easily cleaned out; but where the economizer is not washed out periodically, scale will form. It is much easier to clean it out of the economizer than out of the boiler, and every bit of sediment retained in the economizer is that much less to go into the boiler and form scale.

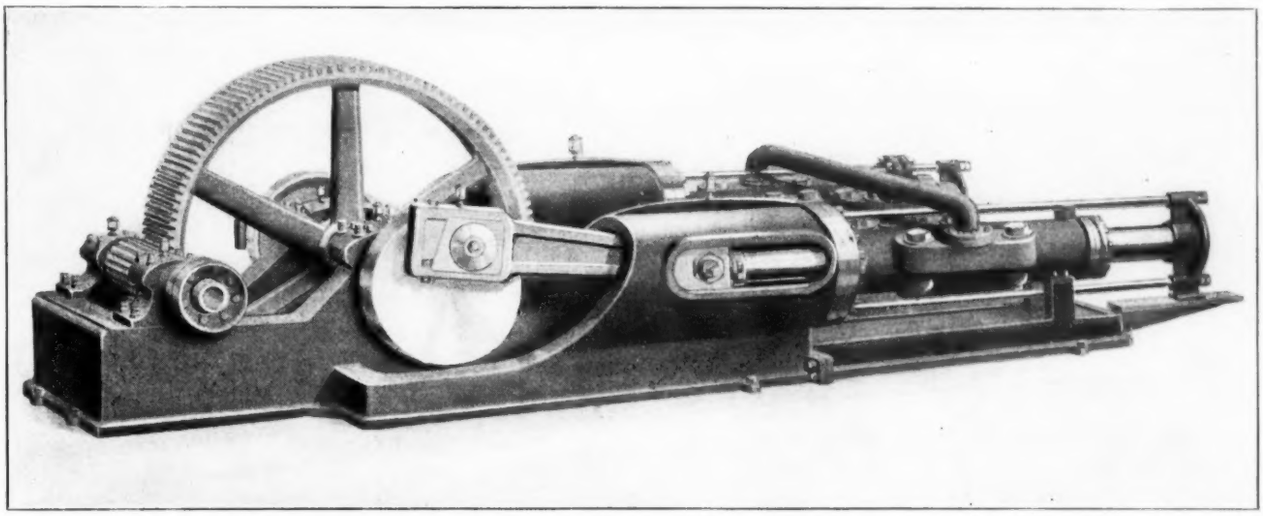
The practice of driving boilers and the use of higher boiler pressures, as well as the rising price of coal, all tend to make the economizer more valuable.

Changes That Take Place in Stored Coal are of two kinds—the oxidization of the inorganic matter such as pyrites, and the direct oxidization of the organic matter in the actual coal. The first changes will result in an increased volume of the coal, and sometimes in an increased weight and a marked disintegration. The changes due to direct oxidization of the coal substances usually cannot be detected by the eye, but as they involve the oxidization of the carbon on available hydrogen and the absorption of the oxygen by unsaturated hydrocarbons, they are the chief cause of the weathering losses in heat value. Numerous experiments have led to the conclusion that this is also the cause of spontaneous combustion. Experiments to show loss in calorific heat values due to weathering indicate that such loss may be as high as 10 per cent. when the coal is stored in air, and 8.75 per cent. when stored under water. It would appear that the higher the volatile content of the coal the greater will be the loss in calorific value and the more subject to spontaneous ignition.—"Steam," B. & W.

Motor-Driven Hydraulic Pump

The illustration shows a recent addition to the line of high-pressure hydraulic pumps built by the Hydraulic Press Manufacturing Co., Mount Gilead, Ohio. It is of the horizontal four-plunger type and designed to fill the requirements for a simple heavy-duty hydraulic pump for supplying a large volume of water or other fluid against a high pressure.

The pump is constructed so that it may be equipped with sixteen different sizes of plungers ranging from 1⅜ to 5 in. diameter, advancing by quarter inches. The water cylinders are made of forged steel for the highest pressures; for the medium pressures (1,500 to 2,900 lb. per sq.in. inclusive) cast steel is used, and for the lowest pressures semi-steel. The pressures range from 9,500 to 700 lb. per sq.in. and the water capacity from 21 to 326 gal. per min. All sizes have bronze valve seats and bronze or nickel-steel valves.



FOUR-PLUNGER MOTOR-DRIVEN HYDRAULIC PUMP

This machine is built for motor drive and requires 150 hp. to operate. It is equipped with a flexible-shaft coupling for motor connection. Any 150-hp. motor having a speed of from 450 to 750 r.p.m. may be used. The speed of the crankshaft is 60 r.p.m. The stroke of the plungers is 16 in., the two cranks are set at 90 deg. Parts such as main bearings, connecting-rod ends, crosshead guides, valves and valve seats, are of easy access for adjustment and replacement. The frame, or pump bed, consists of two heavy castings securely bolted together. The crosshead guides and main-bearing container are machined in this frame. The pump occupies a floor space 18 ft. 8 in. by 6 ft. 10 in.

Animal and Vegetable Oils all have two characteristics in common—they oxidize or gum on exposure to the air and they will cause spontaneous combustion when spread thinly over inflammable material. Linseed oil is an example of a gumming oil—desirable for paint but not for lubricating. All seed oils have this tendency in some degree.

Testing Centrifugal Pumps

By J. Lewis

A recent trip by the writer through the testing department of the Lea-Courtenay Co.'s centrifugal pump works, Newark, N. J., proved decidedly interesting because of several novel instruments and combinations used.

The testing section, at the extreme end of the erecting floor, is shown with the testing crew "in action" in Fig. 1. Beneath the flooring there is a large tank containing water into which the pump suction pipe is extended and into which the pump again discharges. Short lengths of pipe with flanges attached, ready to use, to match up any size of pump, may be seen lying about.

Power for driving the pump is derived from a turbine in preference to an electric motor, partly on account of the ease with which the speed may be varied momentarily and at will or kept constant without the variation caused by fluctuations in voltage, etc. The efficiency of the motive-power machine or the input to the turbine is not considered at all, since it is the power applied to the pump as

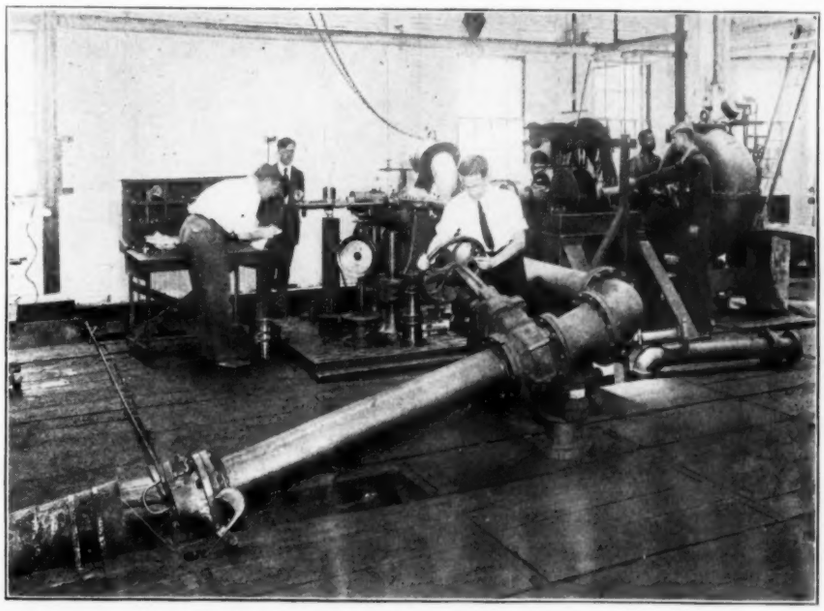


FIG. 1. TAKING OBSERVATIONS DURING PUMP TEST

shown by the torsion dynamometer (described later) checked against the quantity of water handled by the pump at the required pressure, that forms the basis of the power calculation. Steam is supplied to the turbine by

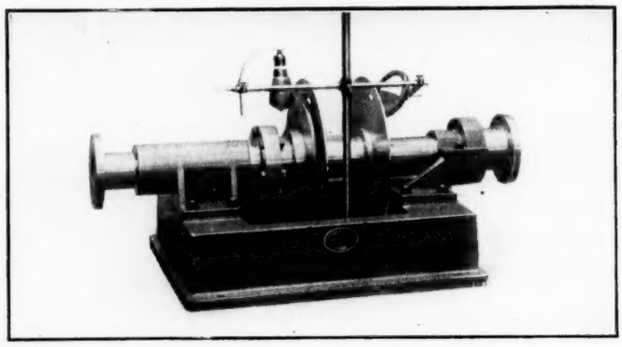


FIG. 2. TORSION DYNAMOMETER

an independent oil-fired 500-hp. marine-type water-tube boiler. The well-known difficulties of using the regular shop plant for testing purposes are in this way obviated, and the delay in getting up steam with coal is done away with by the use of fuel oil. The speed of the turbine is read directly from the tachometer, which may be seen above.

The torsional force delivered to the pump shaft is measured by a torsion dynamometer made in Zurich, Switzerland, and shown in Fig. 2. This instrument consists of a square steel driving shaft that is tested and graduated to allow a certain torsional deflection per unit of force applied, expressed as "inch-pounds." The twisting moment taken with the rotative speed accurately gives the power delivered to the pump. The degree of deflection is read from the reflection, on the mirror at the right, of graduations on a transparent illuminated celluloid disk as seen through the small slots in the disks, one near the electric bulb in the illustration and another corresponding, in the right-hand disk. The optical effect of the openings in the rapidly rotating disks is that of a continuous slot with the point on the scale showing through on the mirror. Several torsion shafts of different strength are kept on hand, so that the instrument has a wide range combined with splendid accuracy.

The efficiency of the pump is determined by the result of the several elements entering in, such as suction lift and resistance, discharge pressure and volume. Tests for small quantities are made by means of Hersey nozzles, while for larger quantities a pitot tube developed as a result of a long series of tests is used. A mercury column 10 ft. high, shown on the wall at the left in Fig. 1, is used in connection with the pitot tube and the graduated nozzles. A small mercury column is connected with the suction pipe to determine the suction head. Ordinary pressure gages are used only to obtain the head pressure; two are always used together as a check, and they are calibrated for each test.

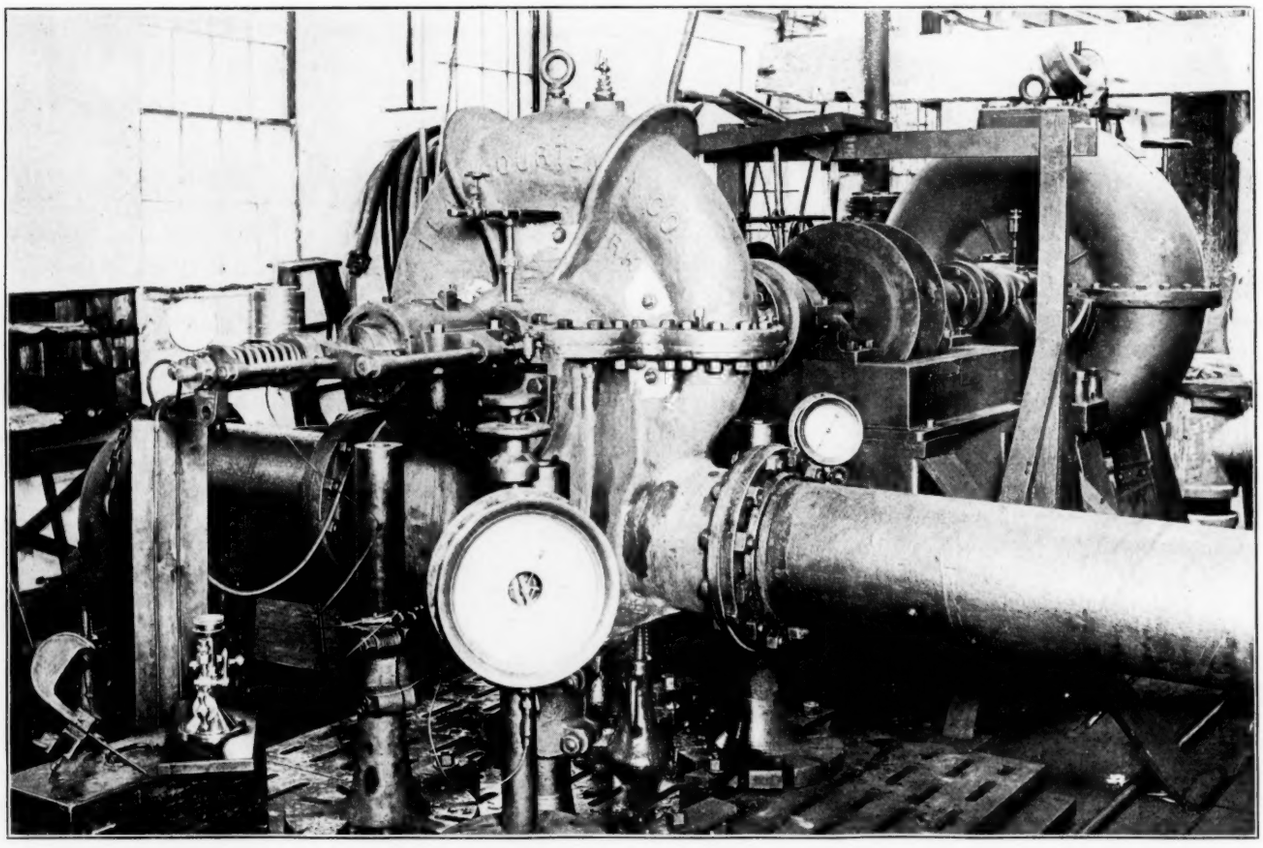


FIG. 3. THRUST METER FOR TESTING THE HYDRAULIC BALANCE

One of the most novel and interesting instruments is what is called a "thrust meter" for measuring, and from its showing intelligently correcting, the end thrust of the impellers. It is claimed that any centrifugal pump, no matter how carefully designed, may have more or less end thrust when first assembled, and in order to eliminate this, its exact amount must be known or else a hit-or-miss

process employed; hence the development of this thrust meter, which may be seen attached to the pump in Fig. 3. The tension on the coiled spring pressing against a special bearing, as indicated by a graduated scale, gives the thrust in pounds, and from this the thrust of the impeller is corrected. It is not an uncommon thing to find, in a double-suction volute pump, that an impeller made as nearly alike on both sides as possible has a large amount of thrust, which is always taken out by adjustment before the pump is passed for shipment.

Diagrams from Air Compressor

By R. S. Hawley

The accompanying indicator diagrams were taken from the air cylinders of a two-stage tandem compressor. Figs. 1, 3 and 5 show the high-pressure diagrams, and Figs. 2, 4 and 6, the low-pressure diagrams. A 40-lb. spring was used for the high pressure and a 60-lb. spring for the low pressure. The valves of the compressor are of the spring-poppet type inserted in cages and the cages screwed into the cylinder head. The lower end of each cage presses against a copper gasket, which prevents leakage at that point.

FIG. 1. VERY POOR DIAGRAM FROM HIGH-PRESSURE CYLINDER

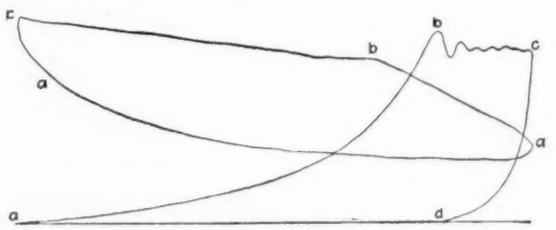


FIG. 2. LOW-PRESSURE DIAGRAM WITH LEAK IN INTERCOOLER INDICATED

Before the diagrams were taken the compressor was pounding badly, its strokes were not uniform and the low-pressure cylinder was excessively hot. Pressure in the receiver could not be maintained as usual, and the consequent decrease in the air supply was noticeable.

FIG. 3. HIGH-PRESSURE CYLINDER DOING LITTLE WORK

Diagrams 1 and 2 were then taken. Fig. 1 shows that the high-pressure cylinder is doing little work. The diagram is so irregular that it is impossible to follow the events of the stroke. The head end of Fig. 2 is nearly perfect in form, but the compression is too high. Air enters along line *da* at atmospheric pressure, is compressed along *ab* to about 60 lb. pressure and is delivered along *bc*. Reëxpansion of air in the clearance space then occurs along *cd*. The crank-end diagram shows that air enters this end of the cylinder at an average pressure of about 30 lb. This indicates a leakage from the intercooler back through the discharge valves into the cylinder.

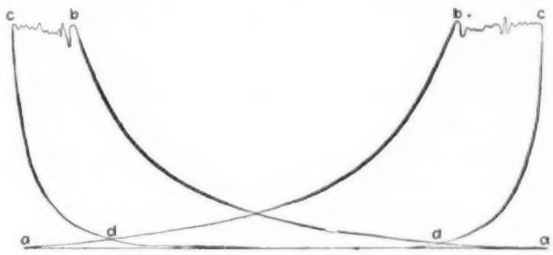


FIG. 4. TOO HIGH DISCHARGE PRESSURE FOR LOW-PRESSURE CYLINDER

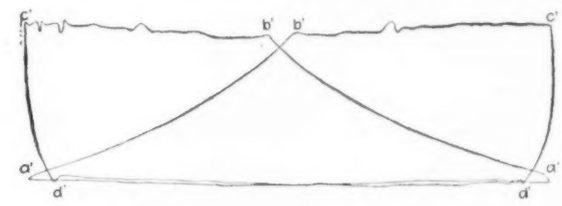


FIG. 5. HIGH-PRESSURE DIAGRAMS—REPAIRS COMPLETED

Examination of the valves on the low-pressure showed that the gaskets under the cages were all defective or broken out, allowing air to pass back into the cylinder from the intercooler. After these gaskets were renewed, diagrams 3 and 4 were taken. Fig. 4 is of good form, but the extremely high pressure of discharge indicates that the valves are operating against practically receiver pressure. Fig. 3 shows that little work is being done by the high-pressure cylinder, and since all the air must pass through this cylinder, considerable leakage through its valves is indicated. Examination of the valves of this cylinder showed that the gaskets were all so badly worn as to be useless, so the piston was simply churning air back and forth while the low-presure was doing all the work of compression. After repairs were made, Figs. 5 and 6 were taken. The compressor is working against too high a pressure for best results.

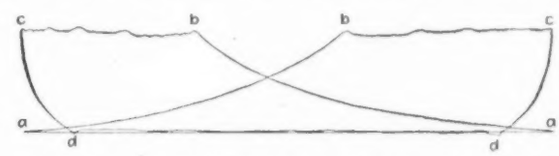


FIG. 6. LOW-PRESSURE DIAGRAMS—REPAIRS COMPLETED

Packing Between a Cylinder Head and the cylinder should be thin, the thinner the better. Thick packing is more likely to blow out, and the additional thickness unnecessarily increases the clearance in the cylinder.

Vibration in Impulse Turbines

By Eustis H. Thompson*

SYNOPSIS—Symptoms and causes analyzed in directory-like style so as to furnish quick reference relative to vibration in impulse turbines.

Just as human ailments are often diagnosed by symptoms, so also are troubles in machinery often located by their indications or characteristics. By carefully considering the conditions observed, the troubles can be absolutely or approximately located.

In applying these rules, allowance must be made for the type of machine encountered; in most cases, however, it is not necessary to place great stress on this, as the general characteristics are nearly alike for all types of turbines. It is not difficult to narrow down the possible causes to a few probable ones and then, by a brief inspection, to find the fault or faults responsible. Noises can be detected more accurately by placing a pipe or rod on the spot to be investigated, and then touching the ear or teeth to the other end.

Bring the turbine slowly up to speed. If vibration appears, the conditions hereinafter described indicate the troubles as listed.

1. Vibration general; no special heating or noises.

   a. Unbalance of rotating parts.
   b. Eccentric coupling or similar coupling trouble.
   c. Sprung shaft.
   d. Sympathetic vibration of foundation or pipe connections.
   e. Improper heating or draining before starting.
   f. Water entering with steam.
   g. Faulty grouting.
   h. Bearings badly out of line (extreme case).

2. Vibration general; no special heating; jingling or pounding noises.

   a. Internal packing rings binding on the shaft.
   b. Revolving buckets rubbing on the stationary buckets.
   c. Loose wheels.
   d. Sprung shaft (bad case).
   e. Coupling trouble (unusually bad).

3. Vibration localized somewhat; local heating, shaft or bearings; no special noise.

   a. Bearing does not fit the shaft.
   b. Packing rings too small for shaft where the trouble appears.
   c. Thrust-bearing trouble, such as insufficient clearance or untrue surfaces.
   d. Oil supply cut off.

4. Vibration localized somewhat; with or without local heating; jingling or pounding noise.

   a. Bearing too large for the shaft.
   b. Loose fit of ball joint on self-aligning bearing.
   c. Oil film breaking down, due to insufficient supply of oil, low pressure, heating, etc.
   d. Loose fit in ball of self-aligning bearing.

5. Vibration localized; no special heating; no special noise.

   a. Loose bolts on the bearing-pedestal block.
   b. Spring in shaft where it goes through the bearing.
   c. Flexibility of bearing pedestal, due to unusual design or foundation peculiarities.
   d. Unbalance in minor rotating parts.
   e. Small bearing troubles in locality of vibration.

Assume good operation up to full speed. Run the turbine at no load for five or six hours with voltage held at zero so that generator has not yet been under voltage. If vibration appears in this interval, look for the following causes:

6. General vibration; no special heating; no special noise.

   a. Water coming over in steam.
   b. Rotating element developing a spring due to effect of expansion on uneven machining of wheel hubs, etc.
   c. Loose construction of built-up wheels.
   d. Ball joint of self-aligning bearing so tight that the bearing cannot align itself with the changing shaft position.
   e. Bearings out of line (unusually bad case).

7. Vibration general; no special heating; jingling or pounding noise.

   a. Rubbing between revolving and stationary blades, due to expansion.
   b. Packing jammed in holders so as to press against the shaft, resulting from expansion of wheel casing.
   c. Loose wheel construction.
   d. Balance weights pulling against each other on both sides of a bearing so as to produce a bad pull through bearing.

8. Vibration somewhat localized; localized heating of shaft or bearings; no special noise.

   a. Bearing pinching the shaft.
   b. Oil trouble.
   c. Thrust bearing binding.
   d. Tight fit on ball joint of self-aligning bearing (not so tight as in 6-d).

9. Vibration somewhat localized, with or without local heating; jingling or pounding noise.

   a. Bearing too large for the shaft.
   b. Loose fit in ball joint of self-aligning bearing, but better than in 4-d.
   c. Oil film breaking down, due to heating, lack of oil, deterioration of oil, or low pressure, etc.
   d. Rubbing of stationary and rotating parts in locality of noise or heating.
   e. Unbalance, bad alignment or bearing troubles in minor parts of the machine.

10. Vibration distinctly localized; no special heating; no special noise.

   a. Loose bolts in the bearing pedestal (not as bad as 5-a).
   b. Flexible bearing pedestal (not as bad as 5-c).
   c. Unbalance, bad alignment or bearing troubles in minor parts, but in less degree than 9-e.

If the turbine set runs well under the previous conditions, build up the voltage to normal and run this way for an hour.

11. Vibration when field current is on.

   a. Loose connections in the field circuit.
   b. Bad alignment of magnetic elements (very rare).

With good operation under the foregoing conditions, gradually build up the load to normal. If vibration appears directly as the load is applied or within five minutes, look for causes as follows:

12. Vibration general; no special heating; no special noise.

   a. Bad alignment of bearings.
   b. Water coming over with the steam.

13. Vibration greater in generator; bad commutation with black bars on the commutator, and often a roaring noise.

   a. Loose joint in the armature winding.

14. Vibration localized; with or without heating; with or without noise.

   a. Rings in first stage packing too tight.
   b. Rotating and stationary parts rubbing in locality of the disturbance.

*Consulting Engineer, Baltimore, Md.

c. Oil film breaking down due to heating or poor oil.
d. Loose bolts in pedestal block.
e. Loose bearing.
f. Mechanical trouble in minor parts.

If vibration appears at any reasonable interval of continuous operation after this time, the following troubles should be responsible:

15. Vibration general; with or without heating; no special noise.

a. Bearings out of line (milder case than 12-a).
b. Machine thrown out of line by expansion of piping, etc.
c. Settling of the foundation, putting bearings out of line.
d. Bad operation of valve gear, admitting steam too irregularly.
e. Water coming over with the steam.

16. Vibration general, with jingling, pounding or roaring noise; with or without heating.

a. Rubbing of revolving and stationary buckets, resulting from expansion.
b. Loose coupling (mild case).
c. Balance weights producing a bad pull through one bearing.
d. Internal packing binding shaft resulting from expansion of the wheel casing.
e. Loose wheel construction (rarely encountered nowadays).

17. Vibration localized, with or without noise; with or without heat.

a. Revolving and stationary parts rubbing in locality of disturbance as a result of expansion.
b. Oil film breaking down, due to heat or insufficient oil.
c. Self-aligning bearing too tight to properly align itself with the shaft.

18. Periodic vibration in generator.

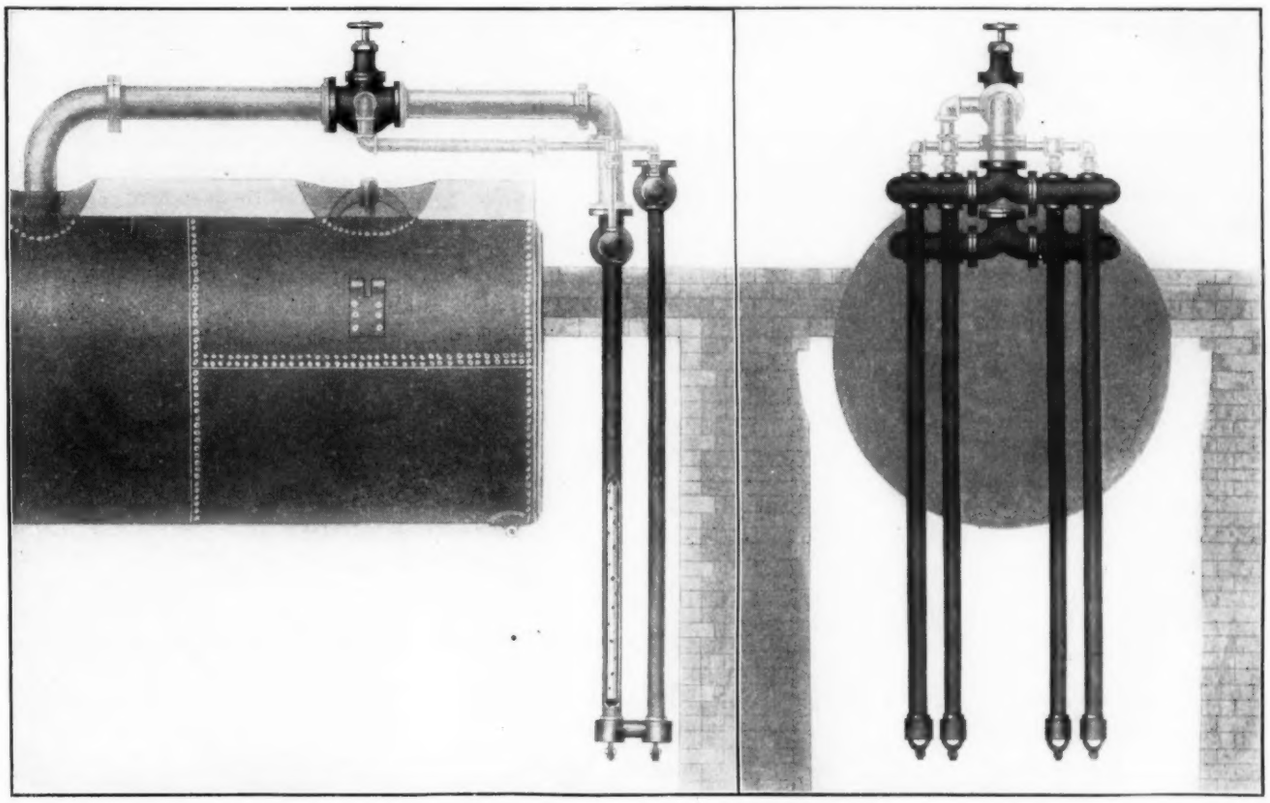
a. If it is an alternating-current generator, look for loose field connection, the same as in 11-a. Sometimes this trouble manifests itself very irregularly.
b. If a direct-current generator, look for loose armature joint, only a somewhat better joint than 13-a.

[The turbine operator or those who expect to operate them would do well to file this article. It may assist them to find the cause of puzzling vibrations.—Editor.]

The Dravo Superheater

A superheater which has been designed especially for application to fire-tube boilers, but which later may be adapted to those of other types, has been perfected by the Dravo Co., 1227 First National Bank Building, Milwaukee, Wis. The object has been to design a simple, durable and inexpensive piece of apparatus which can be readily installed and will bring the benefits of moderate superheat within the range of the average small plant equipped with fire-tube boilers.

As will be apparent in the accompanying illustrations, the superheating tubes pass vertically downward through the rear arch into the combustion chamber. At the top are headers of heavy cast steel placed outside the boiler setting to make them accessible. The connecting pieces are also heavy steel castings and the tubes of seamless drawn steel, the latter being provided with perforated core pipes. By means of a special fitting furnished for the purpose, a differential pressure is maintained between the steam in the main tubes and that in the core pipes. The special fitting reduces the pressure of the steam going into the main tubes by about two pounds, while the steam going into the core tubes is taken from the fitting before the reduction takes place. Through the perforations in the core pipes the steam issues in jets, agitating the steam in the main tubes and bringing it into intimate contact with the heating surface. This agitation and the slow passage of the steam due to large areas make for an efficient superheater.



THE DRAVO SUPERHEATER APPLIED TO A FIRE-TUBE BOILER

Slight Changes Save Time and Money in Ammonia Plant

By Amon J. Fortner

SYNOPSIS—The capacity of the plant greatly exceeds the requirements during part of the season. The management will not install a small machine, and the engineers make inexpensive changes that effect economy.

In a California fruit cooling and storage plant it was found impractical to operate the refrigerating machinery continuously, as the capacity was far beyond the requirements through a greater part of the operating season. Failing in an effort to convince the management of the wisdom of installing a small motor-driven unit to hold down the temperatures during the shutdown period, we engineers decided to make some inexpensive changes that we believed would help the situation.

In this plant refrigeration is supplied to the precooling rooms by means of cold air circulated through a bank of ammonia coils. A fan with a speed of 256 r.p.m. and requiring about 15 hp. was used for this purpose. This fan, together with a 30-ton ammonia compressor and other packing-house machinery, is driven from a lineshaft to which is belted a 90-hp. crude-oil engine. Suitable clutches allow any part of the machinery to be shut down without interfering with other machines.

Fan for Hold-Over Period

By checking up the capacity and power requirements of this fan it was found that at a speed of 100 r.p.m. only about 2 hp. would be required to operate it, and it was believed that at this speed sufficient air would be circulated to at least provide good ventilation during the shutdown period, besides furnishing some refrigeration from the accumulated frost on the coils as well as from the refrigeration contained in the body of liquid ammonia in the flooded coils. Accordingly a small motor was belted in such a way that the fan could be run either from the engine shaft at 256 r.p.m. or from the motor at 96 r.p.m.

Anemometer readings taken after the change was made showed that about 6,000 cu.ft. of air per minute was being handled by the fan at the lower speed, while the power used by the motor was less than the 2 hp. that we had estimated.

The water gage showed about ¼ in. pressure as against 1½ in. on the high speed (256 r.p.m.). The conditions resulting from the operation of the fan in this manner were more favorable than had been anticipated, both in the way of ventilation of the rooms and in temperatures, while other conditions developed that indicated a possibility for greater economy by the use of the little motor in the busy season. All the frost was removed from the coils each night instead of allowing the accumulation to continue until the end of the week as had been the practice previous to this time. Starting each day with clean coils had the effect of raising the average back pressure 10 lb., so that the greatly increased capacity of the ammonia compressor further reduced the necessary running time.

Full advantage could not be taken of this high back pressure, however, owing to the limited capacities of the condenser and cooling tower, which, on account of the increased amount of refrigeration being done, would not hold the high-pressure side down to the safe working limits at all times. Therefore it was often necessary to throttle the suction side of the machine and hold the load off. The engineer's state of mind at these times can well be imagined, especially when one knows that he was anxious to make the best possible showing with the equipment.

At the end of the operating season the cooling tower was reconstructed. It was raised 8 ft. so as to bring it above the roof of the precooling plant. The screens, or mats, were turned round at right angles with the length of the tower and in line with the average wind movement so that the air had to travel only 8 ft. to go entirely through the tower. With a 12-in. space between screens, this arrangement afforded little or no resistance to the free passage of air, both through the tower and upward toward the top.

Our next job was to tackle the circulating pump, which was of the centrifugal type with 3-in. suction and a 2-in. discharge. As the pump was in the basement and several feet below the level of the water in the basin beneath the tower, there could be no uncertainty as to getting a generous supply to the pump. Doubting the wisdom of so small a discharge line for a pump of its size, we placed a gage immediately above the pump in the discharge line. This gage showed a working pressure of 41 lb., and less than half that amount with the pump standing still but with the discharge line full of water. This convinced us that the friction head was far greater than it should be for a comparatively direct line, so we removed the 2-in. pipe and replaced it with 4-in. pipe, of which we had a large quantity on hand. We used a taper connection between the pump casing and the 4-in. pipe so the water would reduce in speed without producing a churning effect. After this change the gage showed a working pressure of 22 lb. with fully double the water going to the top of the tower.

Results of the Change

When we started up the following season, we found that the head pressure had been lowered an average of about 30 lb. and that with the tower improvements the condenser would handle the output of the ammonia compressor at the highest back pressure that we could load onto it.

When the maximum load came on, we changed the program that had been followed in previous years. Where formerly we had run continuously day and night, we now were able to shut down from two to six hours a day, during which the running of the fan on the little electric motor would remove all the frost at a cost of about five cents an hour for power.

This time lost by the ammonia compressor was more than made up by the increased refrigeration performed by reason of the clean coils and high back pressure. We

were actually able to get lower temperatures for the same amount of fruit handled than we had ever been able to get under the old 24-hr. schedule. The capacity of the fan at the slow speed would be given to the newly filled room of warm fruit, while all the other rooms would be shut off during this period.

As we had five rooms in all, this slow speed would give one room alone more air than it would get under the high speed when the air was divided among all five rooms. It was the quick thawing action of this warm fruit that did such rapid work in removing the frost accumulation.

Repairing Brass Plug Cocks

By James E. Noble

Brass plug cocks can often be ground in with flour of emery when they begin to leak. Another way to make them water-tight is to remove the plug, dip it in a strong soldering acid that will make it clean enough to take a tinning over with solder in the usual way. When tinned all over, hold it in a blowtorch or gas flame until the plug becomes hot enough, wipe off all the loose solder and replace in the cock and the job is done.

A plug so treated will usually be liquid tight, but if the cock has been frozen and its shape distorted, it cannot be made tight in this way except in one position. It is obvious that the cock cannot be used for high temperature or pressure steam, but up to 20 or 25 lb. it will remain tight for a long time. Disks made of solder can be used on brass-seated globe valves and swing check valves when the temperature is not too high.

New Duties for the Engineer

By A. G. Drury

If central-station service is to be used, the engineer begins a new set of duties. He should learn all the different contracts the electric company has to offer and their possibilities.

A certain manufacturer, for example, was using 750 kw.-hr. per month purchased at retail rates. On a different schedule of rates, using 1,000 kw.-hr. a month, he would be entitled to what the company termed "wholesale rates," which were considerably lower. He accordingly signed a new contract for 33 per cent. more current than he could use, but he reduced his bills 20 per cent.

The larger power contracts usually embody rates computed on the number of hours' use of the maximum demand, therefore an explanation of this matter may not be amiss. The term "maximum demand" is used to denote the greatest amount of power to be furnished for any given time, expressed in kilowatts, but it could as well be expressed in horsepower. The time may be any period agreed upon—one minute, five minutes, or even an hour, depending on the contract. Suppose that the contract calls for the maximum demand for a five-minute period and a test shows that 1,100 kw. is drawn for one minute, but 1,000 kw. is the greatest amount drawn for five consecutive minutes, the maximum demand should be 1,000 kw.

The maximum demand may be determined by occasional tests or by having a maximum-demand meter or a recording wattmeter permanently connected in the line. Another way sometimes used is to arbitrarily take a certain percentage of the total rated horsepower of all the motors to be driven. Bills for power consumed are usually rendered monthly, and the greater the number of hours' use of the maximum demand during the month the lower will be the rate per kilowatt. The number of hours' use of the maximum demand is found by dividing the number of kilowatt-hours consumed during the month by the maximum demand expressed in kilowatts. The meter reads in kilowatt-hours and that is what is paid for, but the rate per kilowatt is determined as explained.

The schedule of rates may be expressed in various ways. One is to give tables of rates for so many hours' use of the maximum demand; another is a flat charge of, say, $50 per year for each kilowatt of maximum demand, plus one cent per kilowatt-hour of electricity used. No matter how the contract may read, it all works back to the same principle—the electric company desires to sell each customer as much current as can be efficiently used, at the same time tying up or holding in reserve as small a part of the generating plant as possible.

The engineer should be in a position to advise his employer very closely as to the maximum demand and its cost per kilowatt-hour on any given schedule. The main point is to keep the maximum demand as low as possible.

Maximum Requirement Easy If Motors Are Used

If the factory is already electrically operated by its own plant, the engineer can advantageously use some time in taking readings of his switchboard instruments at intervals of one minute until he is thoroughly familiar with the character of the load. If possible, it is well to know the amount of power required by each room or part of the factory. If the factory is belt-driven, he should take indicator diagrams and compute the horsepower from them. The central-station representative will make these tests if necessary and the tests will be right at the time at which they are made, but the engineer should know whether they represent special or average conditions and have his own figures as a check.

If alternating current is to be used, rates may be based on either "primary or secondary" meter measurement. Secondary meter measurement is the current measured at whatever voltage it is to be used, the electric company standing the loss in the transformers. Primary meter measurement means that the current will be metered at high voltage before going into the transformers, and the purchaser pays for the energy lost in transforming the current to the lower voltage. The difference, or loss, between primary and secondary meter measurement may amount to as much as 8 per cent.

The maximum demand and the current consumption are influenced by a careful selection of motors, direct- as well as alternating-current, in regard to make, kind, speed, location, size and number. There are several standard makes of motors, all about equally efficient, any one of which it is perfectly safe to buy.

The selection as to kind, whether a series, shunt or compound direct-current motor, or a squirrel-cage or phase-wound alternating-current motor, depends upon the machine to be driven. If alternating current is to be supplied, use three-phase squirrel-cage induction motors wherever possible, as they are the simplest and hardiest driving machines made and cost the least.

The best rule in regard to speed is to use as high-speed motors as is practical, they are just as reliable, furnish the same power, cost less and are usually more efficient.

If it is the intention to use a separate motor for each machine, the central station expert or the machine manufacturer can advise safely as to size or power required, as there is an abundance of data along these lines. If it is intended to drive several machines with one motor from a lineshaft, the matter becomes more complicated and there can be no definite rule laid down, for each installation presents a different problem.

One way is to take the sum of the individual drives for each machine, making notes of how many machines are operating simultaneously, and calculate the total horsepower of the motors that would be running were individual drive used. An average of several such observations will give the maximum size motor required and one of half this size will probably be large enough. Tests on all sorts of group-drive installations have been made and published by motor manufacturers and the National Electric Light Association and are available on request. Location is determined by given conditions, and about the only general suggestion is to place the motor at or near the middle of the load.

Without considering the relative merits of the group or individual drive, it can be said with certainty that the use of several small motors is more conducive to low electric bills than one large one. This problem can be worked out only by a study of the machines that are working at one time, the lineshafting as it already exists, and the relative costs of several small motors as compared to one large one, together with the necessary lineshafting and countershafts, belts, hangers, etc., and the labor of erecting them.

Wiring a factory has to be done according to certain standards as laid down by the "underwriters" or the city authorities, or both, and it would be well for the engineer to fully inform himself as to these requirements. This work should be placed in the hands of a specialist along these lines, although a few suggestions may not be out of place. The underwriters' code requires a certain minimum size of wire to carry a certain current, and as every factory owner expects his business to increase and require more current, it is best to provide for this increase at the start. Purchasing wire slightly larger than is required is not a dead loss of money, as the loss of electrical energy is less.

There are several minor details and recent innovations that should be investigated: such as the use of circuit-breakers instead of knife or starting switches, the push-button control, and the elimination of belting and overhead lineshafting, all of which are well worth study for the sake of the appearance of the shop as well as the safety and efficiency of operation.

These are only a few of the problems the engineer should investigate, but they give an idea of the new lines incidental to a change in the motive power in the factory. There are numerous others, peculiar to each manufacturing plant, a thorough study of which will be well repaid in the end.

Will Quizz, Jr.

SYNOPSIS—Will finds out why some starting boxes have three terminals and why others have four, also how to connect up a compound motor and put it in operation.

"Good morning, Chief!"

"Good morning, Will! What's on your mind?"

"Oh, it's that new compound motor that has just been bought to run the lineshaft in the machine shop."

"What is there about the motor that is worrying you?"

"Well, to begin with, the starting box is different from those we have had heretofore. It has four binding posts, and the motor has six leads coming out of it. Of course, I tested out the motor and know that there are two leads to the armature, two for the series field and two for the shunt field. What gets me, though, is how am I going to determine whether I have both fields connected properly. You know, if I get them wrong, I won't know it until the shop is ready to start up; and then if it isn't right, there will be a rumpus. Then there is the starting box; it has four binding posts. Between the two I am worried."

"That should not be so hard, Will. Let's see if we have anything in our scrapbook on the subject. Here we have it (Fig. 1). The four posts are marked *LINE+* and *LINE—*; then we have *ARM*, then comes *FLD*. On the other rheostats with which you are more familiar the no-voltage coil is in series with the field, whereas on this rheostat it is placed in series with a fixed resistance *R* mounted on the back of the slate, which limits the current through this coil to a safe value. The whole is connected directly across the line, hence the need for the fourth terminal to make connection to both sides of the line at the rheostat. The remaining connections are just the same as those on any other starting box."

"That's clear enough, Chief; but what is the object in constructing a rheostat in that way?"

"In the first place, a rheostat of this type can be used just as well with a series motor as with a shunt or compound. When used with a series motor you simply make no connection to the terminal marked *FLD*. The holding coil being across the line, it will hold the rheostat handle just the same as long as there is voltage on the line. Then again, take a case where the speed of a motor is varied by variation of the current through the shunt field. In this case the variation of field current is so great that it would be quite a problem to design a retaining magnet to hold the arm at all times. Also, the current taken by the shunt field varies with different types of motors of the same horsepower rating. A slight disadvantage is the fact that it does not afford any protection against opening of the shunt field circuit, although the fuses or circuit-breaker would take care of that. Is that clear?"

"Perfectly."

"All right. Now as to your motor. Suppose we draw a sketch like this (Fig. 2). A compound motor, as you know, is a combination of a series and shunt motor. The only difference is that the series winding on a compound motor is usually not as heavy as it would be on a plain series motor. As you stated a while ago, in order for the fields not to oppose each other the polarity of the field windings on each polepiece must be the same. Suppose

we therefore connect the motor first as a series motor, like this (Fig. 3). Do you get the idea, Will?"

"Yes, sir. But suppose it runs in the wrong direction?"

"Then cross the armature connections (Fig. 4), and the motor will revolve in the opposite direction. You know, of course, that you can run the motor this way for only a moment, as it would run away unless loaded. After you have got the motor running in the proper direction with the series field alone, short-circuit the series field (Fig. 5) and connect the shunt field like this (Fig. 6). Now when you start up this time and the armature does not rotate in the right direction, remember not to reverse anything but the two shunt-field leads. Having done this, try the machine again to see if it is running in the right direction and then you are ready to proceed with the final connection, which is to remove the short-circuit from the series-field terminals like this (Fig. 7). If you remember what I have just told you, I don't think you will have any trouble in making the proper connections."

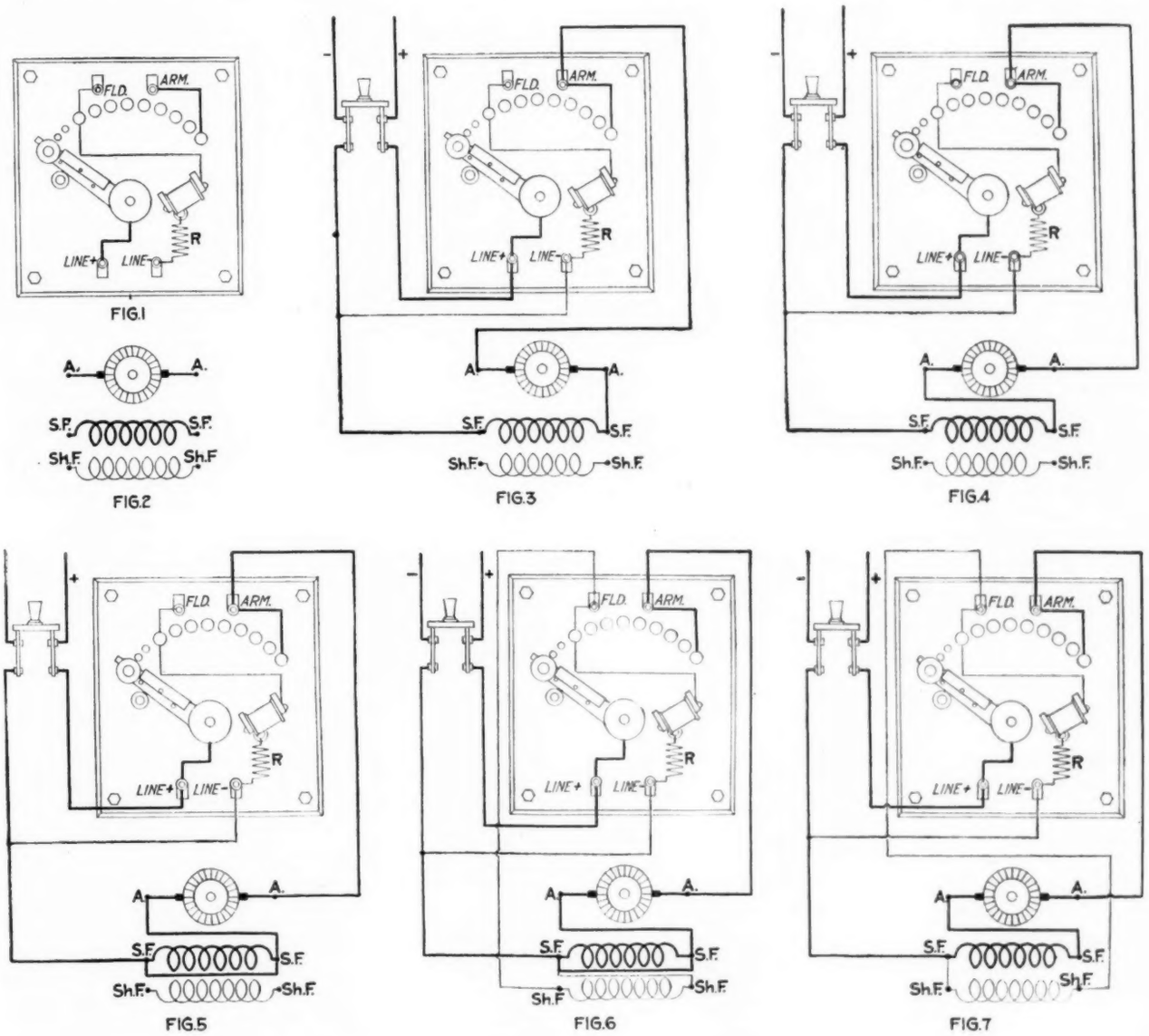
"Thank you, Chief. I'll let you know how I make out in the morning. So long."

Ashcroft Micrometer Lift Gage

With the exception of mechanical reliability, the most vital feature in a safety valve is its relieving capacity. The two factors in a safety valve that determine the relieving capacity are the diameter of the inlet opening at the seat and the amount of the valve life when it is blowing off.

A series of tests made on seven makes of 4-in. standard safety valves to determine the actual lift of the valve when tested with 200-lb. steam pressure showed that there was a variation of 100 per cent. in the lift, thus indicating that some of them, having less than one-third the lift and capacity of others, were rated as having the same relieving value.

An instrument for testing the actual lift of safety valves, known as the Ashcroft micrometer lift gage, is manufactured by the Consolidated Pop Safety Valve Co., 85 Liberty St., New York City. The apparatus consists of an indicating dial graduated in hundredths and half-hundredths, starting at zero and extending through a

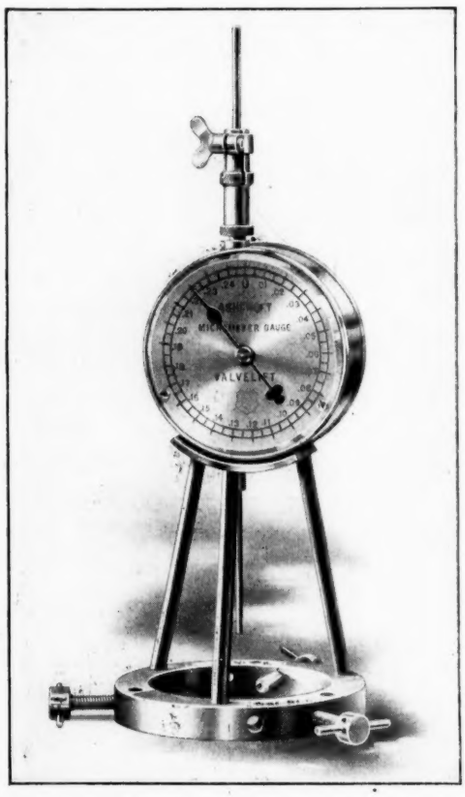


FIGS. 1 TO 7. INDICATE THE DIFFERENT STEPS IN CONNECTING UP A COMPOUND MOTOR TO A STARTING RHEOSTAT

range of twenty-five hundredths of an inch. The hundredths divisions are numbered and spaced ¼ in. apart.

The dial and indicating hand, with the gage movement, are in a brass case having a removable front. The gage case is attached to a frame that is equipped with setscrews, and it can be fitted to the top part of a safety valve in such a position as to bring the gage case directly over the top of the center of the valve.

From the gage case a rod extends so as to bear on the end of the valve spindle or other lifting parts of the valve.



GAGE FOR TESTING LIFT OF SAFETY VALVES

This rod is adjustable so that a zero reading may be had on the dial by means of a threaded sleeve that is clamped with a thumbscrew. As the safety valve lifts, it forces the gage rod upward. This movement actuates the indicating hand on the dial of the gage, the movement being transmitted by means of a rack and gear. The reading of the dial shows the actual lift of the valve during the blowing-off period.

Comparison of Heat Losses from Bare Pipes

By L. B. McMillan

A summary of the results of tests on bare pipes by a number of different experimenters is given in the form of a table. They are also plotted relative to a curve showing results of the writer's experiments.

It will be observed that all the tests check up very closely with those found by me as presented in a paper read at the 1915 annual meeting of the A. S. M. E. and published in *Power*, Apr. 4, 1916, p. 469. In fact, my curve strikes a good average between all the other results, which were obtained by condensation methods while mine were obtained by an electrical-test method.

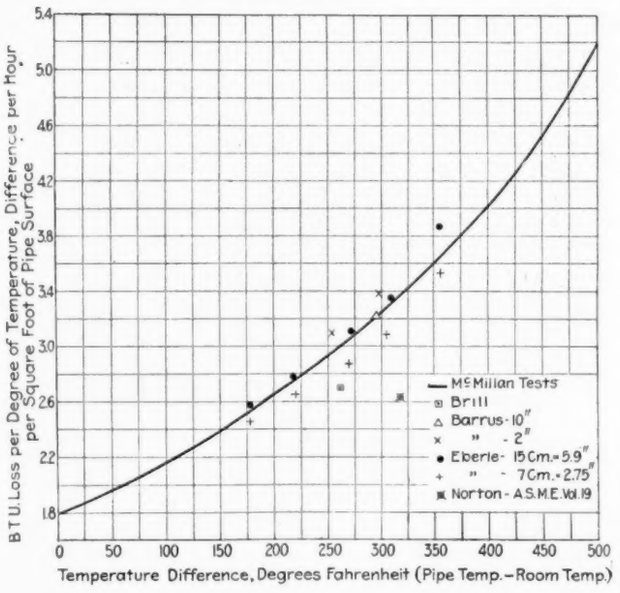
I am also including a copy of the results of a test made by me at the University of Wisconsin on the new J.M 85 per Cent. Magnesia as it is made at the present time. The material that I tested previously, the results

RESULTS OF TESTS OF BARE PIPE LOSSES

Authority	Pipe Size	Temperature Difference, Deg. F.	B.t.u. per Sq.Ft. per Deg. Temp. Dif. per Hr.	
G. M. Brill (Trans A.S.M.E. Vol. 16, p. 827)	8 in.	263 to 286	2.706	
Geo. H. Barrus (Trans A.S.M.E. Vol. 23, p. 791)	2 in.	296	3.366	
	2 in.	254	3.081	
	10 in.	296	3.220	
			70 Mm. = 2.75 In.	150 Mm. = 5.9 In.
Charles Eberle (Mit Uber Forschungs-Arbeiten auf dem Geb. des Ing., heft 78.)	70 mm. and 150 mm.	180	2.46	2.54
		216	2.67	2.73
		270	2.90	3.12
		306	3.14	3.37
		360	3.56	3.89
C. L. Norton (Trans. A.S.M.E. Vol. 19, p. 729)	....	318	2.61	
L. B. McMillan (Trans. A.S.M.E. Vol. 37, p. 921, and Power, Apr. 4, 1916)	5 in.	50	1.950	
		100	2.152	
		200	2.665	
		300	3.260	
		400	4.035	
		500	5.180	

TEST BY L. B. McMILLAN OF NEW J-M 85 PER CENT. MAGNESIA, FEB. 28 TO MAR. 2, 1916

Temperature Difference	B.t.u. Loss per Sq.Ft. per Deg. Temp. Dif. per Hr.	Efficiency
50	0.372	81.0%
100	0.380	82.3
200	0.398	85.0
300	0.414	87.3
400	0.427	89.4
500	0.442	91.4



RESULTS OF TEST BY VARIOUS EXPERIMENTERS

of which were reported in my paper, was covering that had been in stock at the university for several years and does not represent the kind made at the present time, and should not be regarded as applying now.

Dashpots of Corliss Engines should have a plentiful supply of machine oil or oil of a heavy grade, or else glycerin. The temperature of the engine room will dictate to some extent the heaviness of the oil.

Log Sheets enable the engineer to keep in touch with the operation of the plant and to determine if it is working at the highest efficiency. This log of itself has no value unless it is carefully analyzed from day to day to determine whether the plant did maintain the highest efficiency on each particular day under the conditions at which it was necessary to operate

Chart for Determining Heat Loss in Flue Gases

By H. F. Hutzel

The accompanying chart affords a simple means for determining the heat loss in flue gases. This chart is based upon the following formulas:

$$W = \frac{4 \times CO_2 + O_2 + 700}{3(CO_2 + CO)} \times \frac{C}{100} \qquad (1)$$

in which W represents the pounds of flue gases per pound of coal burned and C represents the percentage of carbon in coal. CO_2, O_2 and CO represent, respectively, the percentages by volume of carbon dioxide, oxygen and carbon monoxide found in the flue gases.

$$H = W \times 0.24(T - t) \qquad (2)$$

in which H represents the heat lost in B.t.u. per pound of coal burned and (T — t) represents the difference in temperatures between the flue gases and room.

$$P = \frac{H}{K} \qquad (3)$$

in which P represents the loss in per cent. and K represents the calorific value per pound of fuel as fired.

Since the percentage of oxygen is an indication of the amount of excess air that is being supplied to the furnace, it would naturally be supposed that the abscissas of this chart should represent O instead of CO. The reason for having abscissas represent CO rather than O is as follows:

In the formula given for determining the weight of flue gases, it will be observed that there are three variables; namely CO_2, O and CO, which vary as the state of combustion varies. With these variables almost an infinite number of combinations might be formed,

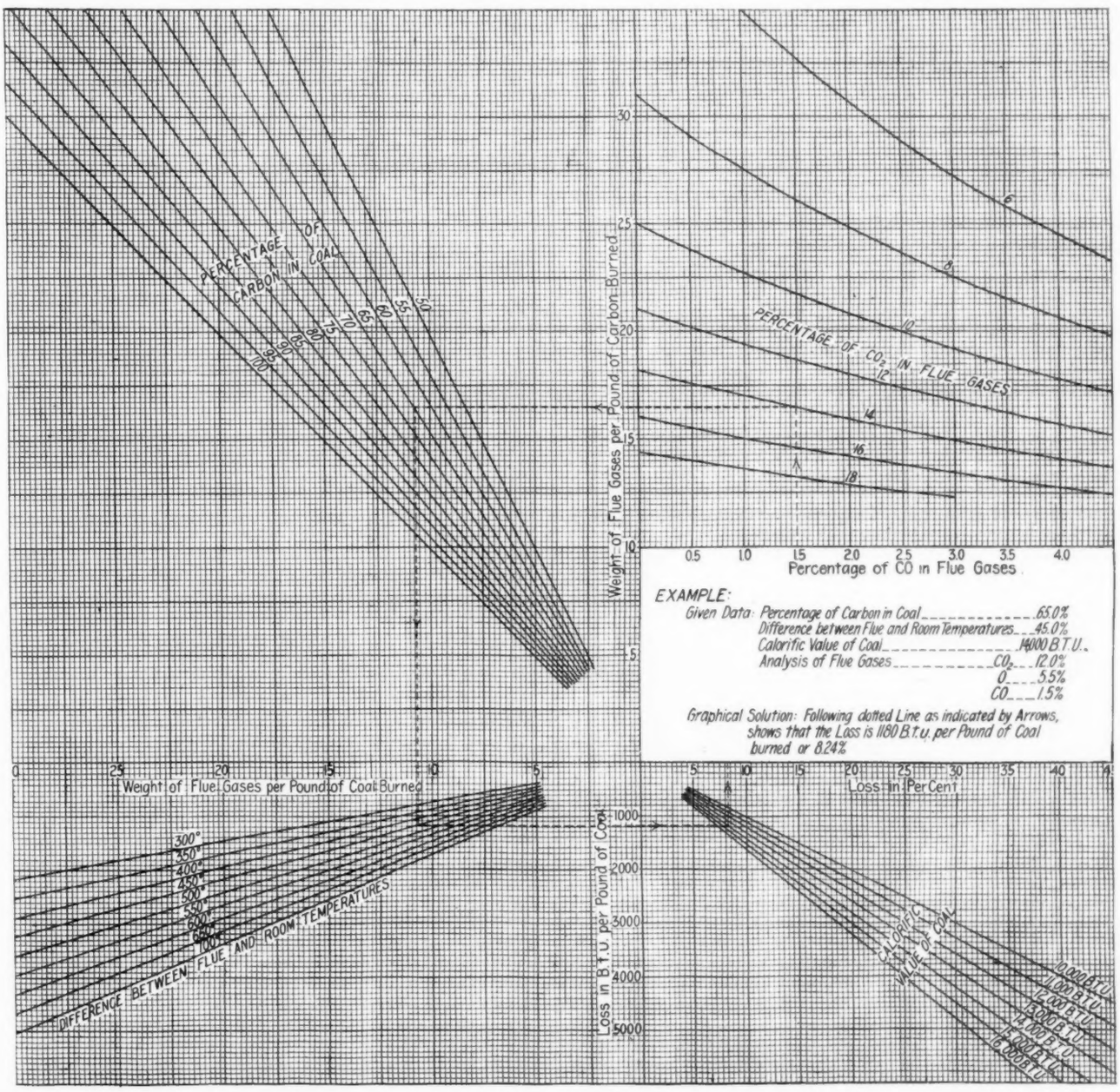
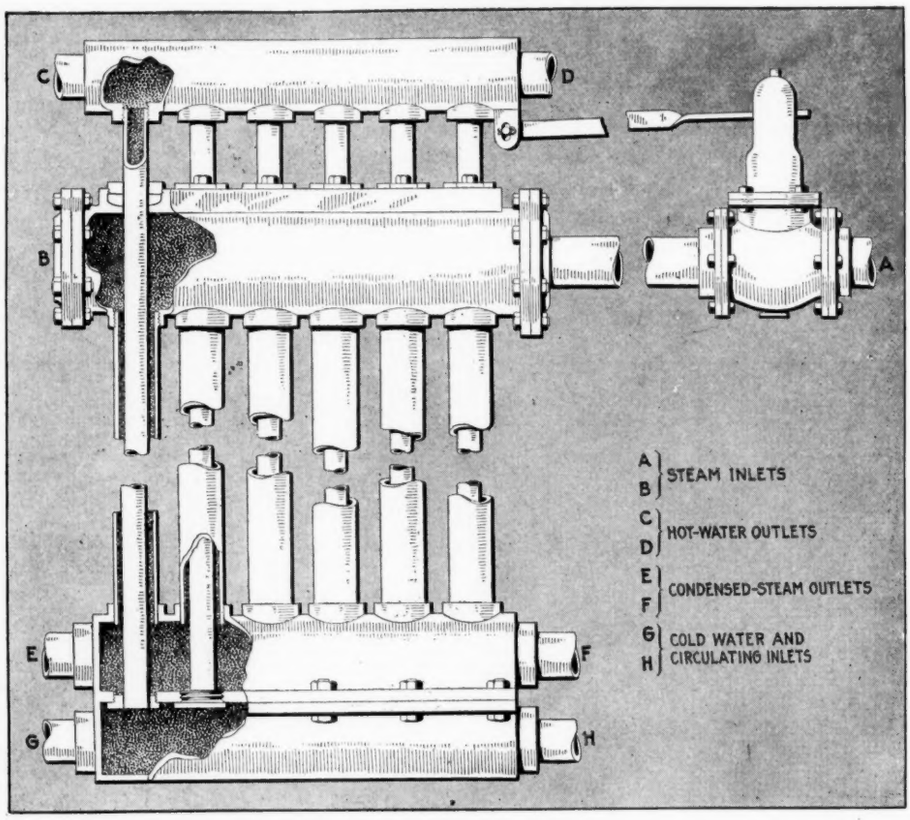


CHART FOR DETERMINING HEAT LOSS FROM COMBUSTION OF COAL IN BOILER FURNACES

therefore making it almost impossible to produce a chart for determining flue-gas losses that would cover all cases.

In order that the accompanying chart might be made to cover any example, I have made an assumption that is neither theoretically nor practically correct, yet the error introduced is so small as not to affect the accuracy of the readings on the chart more than a fraction of one per cent. The assumption made is that the sum of the percentages of CO_2, O and CO, as indicated by the flue-gas analysis, is 21 per cent. for all samples. This sum might be somewhat less, owing to hydrocarbons in the fuel, but even then should not total less than 19 per cent. In case of the presence of CO, the sum might be more than 21 per cent., but seldom does it exceed this amount. That the assumption made might introduce as small an error as possible, the percentage of oxygen as shown in equation (1) was determined by subtracting the sum of the percentages of CO_2 and CO from 21. From the formula it will be observed that the numerator for any analysis will be much greater than the denominator. Therefore, even though the percentage of oxygen as determined by the foregoing method is incorrect by a small percentage, the value of W will hardly differ from the true value. On the other hand, should the value of CO have been determined as that of the oxygen, any slight error might effect an appreciable error in W, since the CO appears in the denominator.



DETAILS OF MADSEN AUTOMATIC WATER HEATER

Madsen Automatic Water Heater

There is a demand for large quantities of hot water in a considerable number of steam plants where a supply of exhaust, low- or high-pressure steam is available. A method of heating this water without the use of storage tanks, and one that insures a continuous flow of hot water, is that of the Madsen automatic water heater, manufactured by the Thermal Appliance Co., Inc., 240 West 27th St., New York.

The heater consists of a compound header at the bottom, a central steam header and a hot-water header at the top. The compound header receives cold water from both ends, and it is circulated through the brass tubes to the hot-water header. These tubes are anchored at one end to the division wall of the compound header. Their opposite ends have a free movement through stuffing-boxes in the central steam chamber and are screwed into the hot-water header.

Steam enters through the steam-inlet pipe to the steam header and passes down through the pipes that incase the brass tubes connecting the compound with the hot-water header. All condensation passes out through the outlets of the top part of the compound header.

When the water in the heater is cold, the brass tubes are contracted. This brings the header to its lowest position, and the movement causes the fulcrum lever to drop at the header end and rise at the valve end, allowing the valve to open. Steam then flows to the steam header down past the brass tubes and into the condensed-steam chamber of the compound header. As the water in the brass tubes becomes heated, they expand slightly, which action moves the fulcrum lever and causes the steam-inlet valve to partly close. As soon as the hot water ceases to flow through the brass tubes, the valve is automatically closed by their expansion. Thus steam is used only when hot water is being drawn from the heater. All condensed steam may be returned to the boiler by any handy means, or through a trap into a drain if it is oily.

This heater is made in five sizes, from one to eight pipes wide and 18 ft. in length. It covers a range with low- and high-pressure steam of from 100 to 8,400 gal. of hot water per hour, according to the size of the heater.

The headers are all made of cast iron, with wrought-iron steam pipe and brass cold-water pipes. Each heater is tested to 200 lb. hydrostatic pressure.

The Specific Gravity of oil is compared with water taken as unity. As regards determining the value of an oil as a lubricant, specific gravity is of no value whatever. It is useful in determining the purity of some oils—vegetable for instance. Olive oil should have a specific gravity of 0.917, and if it should fall below or exceed this, it has probably been adulterated. The specific gravity is obtained by means of a chemical balance and gravity bottle, or where there is a sufficient quantity, by means of a hydrometer. The temperature at which this is usually taken is 60 deg. F.

Editorials

The Adoption of Standards

One of the slogans in the electrical industry today is standardization. This is voiced from the platform of most every electrical engineering society. The manufacture of electrical machinery has been to a considerable extent standardized, but there are many other features of the industry that have not. One of the amazing facts about this whole subject is that none of those interested makes a demand for standards until the entire industry is laboring under an aggregation of devices and schemes for accomplishing the same thing, and none of them interchangeable, or if at all, only with considerable inconvenience and expense. For example, the standardization of frequencies was not given serious thought until it became desirable that all the needs for the electrical energy of a community be supplied from the same source, which meant that many existing systems be tied into one. This became a difficult problem on account of the various frequencies of the different systems, many of which were not interchangeable. It is surprising to learn that when the strongest demand is being made for a standard frequency for alternating-current systems other periodicities are coming into existence, as witnessed by the 36-cycle system of the Yadkin development.

Every public-utility company wished to go its own way as to what was a just and adequate service to the community that it served, until public-service commissions began to come into existence, which made it possible for the public through these commissions to question the adequacy of the service; and in many cases the utility companies were forced into long and expensive litigations. This awakened the utilities to the necessity of some standard of dealing with their customers so that the public will know that it is getting what it is justly entitled to and the public-utility companies may avoid litigation and investigations.

With the examples of the necessity for standardization and the knowledge that it is in all cases essential sooner or later in every branch of the industry, we find that the public-utility companies and engineering societies do not seem to desire these standards until absolutely necessary. One of the most recent illustrations of this was the opposition offered to the National Electrical Safety Code promulgated by the Bureau of Standards, Washington, D. C. One of the chief objections raised to the adoption of this code was the mediocrity of the type of men, with exceptions, that will be required to administer the rules if universally adopted; and if changed to meet local conditions, the power companies would have to contend with a political and engineering conglomerate with its well-known inconsistencies. The State of California has seen the need of an electrical safety code and has just issued "Tentative Electrical Utilization Safety Orders," prepared by a committee representing various interests related to the manufacture, installation and operation of electrical equipment, at the request of the Industrial Accident Commission of the state. Therefore it would seem that the argument given against the adoption of the National Electrical Safety Code is somewhat inconsistent, and that instead of the utility companies having to contend with a national, as they put it, political and engineering conglomerate, they will have to deal with a different safety code in each state administered by the political and engineering conglomerate of a particular state. This is just the experience of the railroad companies at the present time, and one of their appeals is, "Free us from this mass of state regulation and give us national control." It therefore seems pertinent that the public-utility company operating in several states will find it much easier to comply with a national safety code than with a different code in each state, and now is the opportune time to get together and insist upon such a code.

Equipment Versus Men

Power-plant instruments are merely the tools of the proficient engineer. The owner who fancies that a liberal expenditure for indicating and recording devices in itself insures efficient operation is deluding himself, for only through the effective combination of men and equipment can the desired results be attained. No tools can be too good for the skilled craftsman, but the policy of investing in plant at the expense of salaries can be carried too far.

It takes no mind reader to see that some directors believe that if uptodate machinery built by the best makers is installed in a plant, the question of compensation, and consequently the caliber of men who are to operate it, is of secondary importance. This does not apply so much to the big stations, but it is now and then to be seen in medium- and small-sized plants where those in control of finances look upon the engineer as a cross between a janitor and a plumber. Refinements in equipment are of increasing importance, but they never can take the place of intelligent, enthusiastic devotion to duty on the part of the personnel. The slot-machine type of power plant is a long way from realization, and no conclusion could be more fallacious than that the multiplication of automatic equipment reduces the necessity for expert supervision of the power-production process.

The last thing an engineer should be discouraged about is the fact that his neighbor is equipped better than he as to plant material. It takes real ability to develop power at a lower unit cost in an older station than in a new installation bearing the mint-mark of the brightest minds in the designing field, but it has been done over and over again.

Is it not strange that the value of engineering services is so often overlooked? It is often stated that the general tendency is toward a standard of accomplishment lying quite within the reach of mediocre men and that automatic mechanism eliminates the need of the highest mechanical intelligence in plant service. Such a view is utterly superficial; it fails to consider the never-ending problem of depreciation, the continual demand for the exercise of skilled judgment in plant administration, executive rela-

tions within organizations, the trend of future plant development in relation to prospective demand, and the study of one's installation as an engineering-experiment station. The university laboratory is not the only place where research can be conducted, and the big stations have no monopoly of brains, though they naturally draw into their service men of proved records in lesser responsibilities.

Many engineers have heard the call of opportunity in the midst of outwardly unfavorable conditions, in poor little plants never honored by visits from consultants of national repute. Starting with slender resources, many an engineer has faced the problems of his service with a grasp and imagination that have carried him forward into spheres of usefulness where the old handicaps have fallen away, where his recommendations compel respect and where the combination of his personal ability and the equipment at his disposal has become an irresistible means of rendering efficient service to his employers.

The Cost of Coal

In an interesting paper on the cost of coal, under the joint authorship of George Otis Smith and C. E. Lesher, United States Geological Survey, before the American Mining Congress in Chicago recently, several striking points were brought out. One was that the per capita annual expenditure for the useful metals is roughly equal to that for coal. While comparatively few buy pig iron, none is spared the necessity of buying coal in some form, this nonindustrial consumption in cities reaching nearly two tons per capita, while the total per capita consumption last year amounted to over four and one-half tons. The cost of metals is usually charged to capital outlay rather than operating expense as in the case of coal; it is therefore less keenly felt and public sentiment is more easily aroused on the subject of coal.

It appears from this paper that the cost of coal per ton in several of its essentials may be obtained easily, since the details of mining costs, once considered sacred from public view, are now freely discussed by mine operators and the transportation cost can be learned from the Interstate Commerce Commission by simple inquiry. These costs naturally differ in different fields and even in adjacent mines in the same field, since both nature and man contribute to such variation. The cost of selling may vary from nothing, where the producer consumes his own product, to fifteen cents for specially prepared sizes for retail trade. The average cost for the transportation of bituminous coal to its market is about two dollars per ton, and for anthracite it is higher because the distance is usually greater. Thus it can be seen that coal like all other commodities has a "place value" that may vary greatly, as it passes through the hands of the wholesaler, the jobber and the retailer en route to the consumer's coal bin, paying commission and suffering shrinkage all along the line.

The wastefulness of long hauls, in some cases actually past other mines, is characterized as "burning coal to haul coal past coal," and it is suggested that possibly by slight changes in equipment the consumer may find coal from sources nearer home equally satisfactory. Professor Mead, of the University of Pennsylvania, is quoted as authority for the statement that the delivery of coal is costing the dealers fifty cents a ton more than is necessary.

The authors considered the major item in the present-day cost of coal the ever-enhancing "resource cost," or what the operator has to pay for the coal in the ground, in the form of royalties or depletion charge. One of the latest large leases provides for the payment to the lessor of 27 per cent. of the selling price of the coal at the breaker, against a minimum of about 10 per cent. in some of the old leases, and the tendencies are still upward. The value per acre of anthracite land is shown to have increased from two dollars at the beginning of the last century to fifty dollars by 1850 and by 1875 to five hundred dollars; and now there is little to be had at three thousand dollars per acre. The fortunate owner of coal land is evidently prone to "get all that the traffic will bear," and the penalty imposed by the state for high royalties is higher taxation, which in turn is urged in justification of still higher royalties *ad infinitum*, plus the interest charge that accumulates throughout the period between the purchase of the land and the removal of the last ton of coal therefrom.

The policy of the National Government in retaining the ownership of public coal lands at least up to the time when market conditions justify opening the mine is based on the foregoing; namely, the accruing interest charge. An illustration is furnished by an actual experience by the Geological Survey in the valuation of coal land belonging to the Choctaw Indians—that four to six millions invested would have to return one hundred and sixty millions in royalties to balance the account when the operation was finally completed.

The "ultimate consumer," after looking the situation over, seems to have only "Hobson's choice" and must inevitably "eat crow." Adapting the plant to the use of cheap fuel and practicing the utmost economy seems the only way to avoid an excess of that unsavory diet.

The Westinghouse Memorial

Between two somber ridges of mountainous hills a little more than a half-hour's ride out of Pittsburgh stand the huge works that bear the name of Westinghouse.

You may speak of solenoid brakes or band brakes and they conjure no names; but to mention air brakes and not think of Westinghouse is as impossible as to say Cheops and not think of the Pyramids. Scattered throughout the country are factories and offices whose electric signs blaze the name of this distinguished engineer who, besides being that, possessed the business ability and imagination to be the animating spirit of the gigantic industry that bears his name.

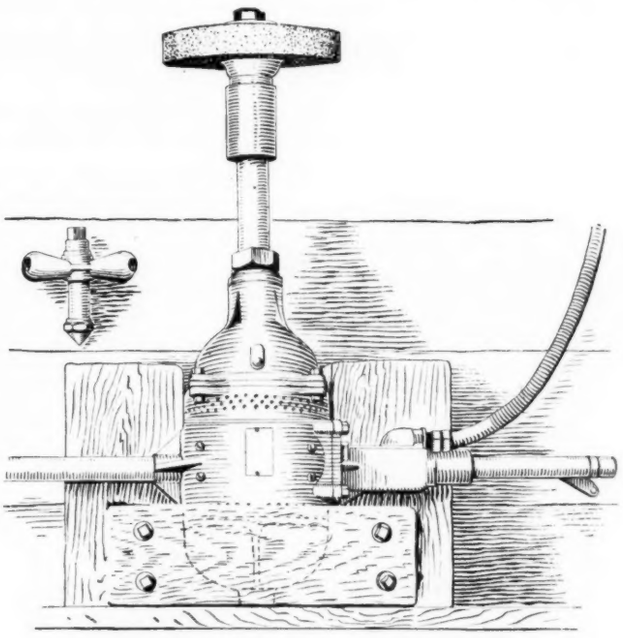
What more fitting thing than that the Engineers' Society of Western Pennsylvania should give the initial impetus to a movement to buy the Pittsburgh home of George Westinghouse and turn it into a public park, to be known as the Westinghouse Memorial Park and to be maintained by the city. It is a tribute to an engineer worthy of it, and we congratulate the society.

The latest coal-saving dope is Fyrox, and it is a safe bet that it is no better than any of the long list—Kemkom, Calorigene, Carbonine, Kol-Saver and a lot of others that have flourished for brief periods, parted a number of victims from their good money and gone into the limbo

Correspondence

Air Drill Cleaning Tube Caps

The illustration shows how we use an air drill for cleaning and truing up water-tube boiler caps. The air motor is fastened to the bench between two blocks of wood and held down by another so that the shaft extends just beyond the side of the bench in a convenient



AIR DRILL FASTENED TO WORK BENCH

position. A small carborundum wheel is attached to a spindle with a standard drill shank to fit into the motor-spindle socket. The caps are quickly and thoroughly cleaned by simply holding them against the side of the grinding wheel. Care must be taken not to use too coarse a wheel or the face of the cap may be spoiled. An electric motor may be used in the same way as the air motor in this case. F. F. Sengstock.

Chicago, Ill.

Motor Would Not Start

The failure of a continuous-current motor to start is usually due to one of several conditions, among which are the following: A dead line, an open-circuit, a short-circuit, a ground, low voltage and an overload. In case of a dead line or an open-circuit, unless the open-circuit happens to involve the shunt-field winding, there will be no sign of a flash when the starter is thrown on and off. In the case of low voltage, short-circuit, ground or of overload, however, there will be a flash when the starter is thrown on and off. In all cases except that in which failure to start is due to an excessive load, the trouble may be readily located by checking the connections and by testing the voltage and the insulation. The condition of overload in starting usually is not so easy to determine unless the motor is also found to be overloaded when running. Occasionally local conditions like the following suggest the cause of the failure to start.

A direct-current motor, which was used for the pumping of water and which was controlled by means of an automatic controller that was adjusted to close the motor circuit when the water pressure reached a minimum of 40 lb. and to open the circuit at a maximum of about 60 lb., was complained of because it would not start. Troubles as reported often need qualification, and in this particular case "would not start" meant that the operator had left the motor running all right one night and the next morning found the pressure well below the starting value, the motor stopped and apparently was unable to start. An inspector found that the apparent inability to start was due to a fuse having blown. On replacing the fuse, the motor started all right and promptly pumped up the pressure; but the pressure switch failed to operate even when the pressure had reached 75 lb. Above this pressure the decrease in the motor speed was plainly evident, and a grinding noise emitted by the motor indicated overload conditions; had the motor been permitted to continue to run, the fuses would have again blown.

The whole trouble was due to the fact that someone had been tampering with the pressure-switch adjustment and had raised the cutting-out pressure to a value that overloaded the motor and caused its fuses to blow before the pressure could reach the value at which the switch would act. On readjusting the switch, operation became normal. E. C. Parham.

Brooklyn, N. Y.

Water Power and Oil Question Before Congress

Congress is about to decide, in the session which opened Dec. 4, whether natural resources belonging to the people, and officially valued at hundreds of millions of dollars, shall or shall not be given away to certain special interests which are already rich enough. Unless the people take a hand, the decision is sure to go against them.

The iniquitous Shields water-power bill has passed the Senate. It makes a present of the public water powers on our navigible streams to the water-power interests. The power thus handed over without compensation is estimated at sixty million horsepower, or double the power of every kind now used to run every train, trolley, factory, shop, mill, boat, mine and electric light in the United States.

While the grant is ostensibly limited to fifty years, it is in fact perpetual, because the conditions under which the people might regain control of their property are made prohibitory, as even advocates of the bill frankly admit. In practical effect a perpetual monopoly is given away for nothing.

This bill has also passed the House, but in a different and better form. It is now in conference. We know from the statement of Senator Nelson on the floor of the

Senate that the friends of the water-power interests expect to control the conference.

A vigorous effort was made to pass this indefensible raid on the public property while public attention was fixed on the international crisis last winter. It failed because editors of the country came to the defense of the public rights, and the bill was postponed until after election.

Another vicious measure is the Myers bill, which does for water powers on public lands what the Shields bill does on navigable streams. The two are cut from the same piece of cloth and have the same interests behind them. The Myers bill is on the Senate calendar and will be considered early in the coming session.

These two bills give away public property to powerful monopolists. That is bad enough, but the oil-land provisions of the Phelan bill are even worse. This bill will be taken up shortly. It disposes of vast areas of public oil lands on terms unfair to the public. It is almost unbelievable, but this measure actually gives away the fuel-oil reserves of the United States Navy to claimants whom the Supreme Court recently declared to have no legal rights whatever. The efficiency of the Navy, our first and most important line of national defense, is to be sacrificed to the profits of the Standard Oil Co., the Santa Fe Railroad interests and a few other claimants, who want what they have no right to get.

As to this, the Navy Department has officially said:

> Oil-burning naval vessels possess such manifold military advantages over coal-burning vessels that it would be practically suicidal from a military point of view for the Navy Department to abandon the policy of building oil-burning ships; but the demand that this legislation be enacted and the support that this bill has received have caused the Navy Department to seriously consider the advisability of abandoning this policy, and thus design ships known to be inferior to ships which a country possessing an oil supply can build.

These bills have made such progress that the advantage of position is with them and against the public. Every effort will be made to jam them through at the beginning of the short session of Congress. Powerful water-power and oil interests are fighting for them. I appeal to citizens interested in the public welfare without regard to politics to lend a hand in defeating these attacks on public property and on the safety and welfare of the Navy and the nation.

GIFFORD PINCHOT.

Washington, D. C.

Desires Further Discussion on Diesel Engines

I have read with a great deal of interest Jan Spaander's contribution on page 695 of *Power* for Nov. 14. Inasmuch as Mr. Spaander has very kindly furnished me with so logical an analysis, although necessarily somewhat brief and condensed, I desire to thank him through the columns of *Power*.

The desire for just such information was primarily responsible for my letter in the Oct. 10 issue. Although it may have appeared rather severe, I have no apologies to offer and still adhere to my original statements, which can be verified from the records kept by myself and my predecessor at this plant.

I have been informed that many operators and owners of Diesel-type engines, both vertical and horizontal, are obtaining reliable and economical service from their units, such as was related by C. Dickerson in the Oct. 31 issue of *Power*.

There is no reason why this type of prime mover, properly designed and constructed, furnished with adequate lubrication and attendance, should not be fully as reliable as any form of prime mover in modern use, within its limitations as to capacity, etc.

I should like to know of and see a double-acting engine, either vertical or horizontal single- or multi-cylinder operating on the Diesel cycle. Also I should like to see a vertical engine with an open frame built up of steel sections similar to some types of vertical steam marine engines in use today. It appears to me that the principal strains induced in a frame of this type are tensile strains, which might better be absorbed by steel frames than frames of cast iron such as are used by American builders. The total cross-section would, it appears to me, be considerably less in the case of steel frames. I refer, of course, to the single-acting four-stroke-cycle type of Diesel engine.

I should be glad to see these points discussed by competent men, as my knowledge along this line is limited, particularly as to structural requirements of engine frames operating under the pressures and temperatures encountered in Diesel practice.

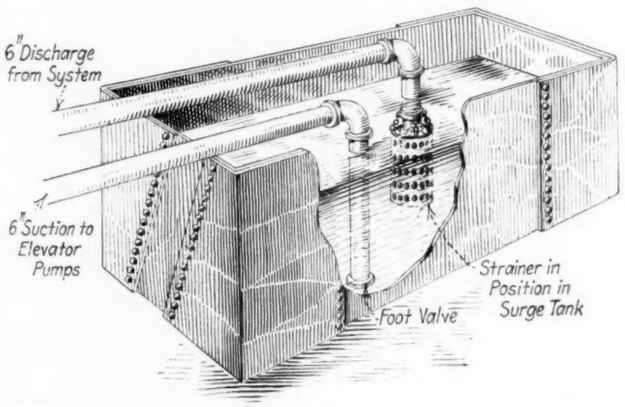
H. R. WASS.

St. Louis, Mo.

[Considerable experimental work on the double-acting Diesel has been done by European builders and a few commercial engines put out, although they are not in general use. Moreover, one American builder is now experimenting with the double-acting engine. There are several marine Diesels of the open-frame construction.—Editor.]

Pilot-Valve Trouble on a Hydraulic Elevator

One of the troubles on a high-pressure hydraulic elevator system is caused by particles of flax packing used in the plunger stuffing-boxes breaking off and being carried through the pipes. These particles stop up the port-



RETURN TANK SHOWING POSITION OF STRAINER

holes or strainers of the pilot valve, causing the car to slide past the floor and necessitating frequent shutdowns until they can be cleaned. A car in this condition is very unsafe, as the operator cannot control it properly.

To remedy this defect a copper strainer about 3 ft. long and 10 in. diameter was made and placed so as to hang from the end of the discharge pipe in the return tank, as shown in the drawing. It is composed of a perforated sheet of copper $\frac{1}{8}$ in. thick with holes $\frac{1}{32}$ in. in

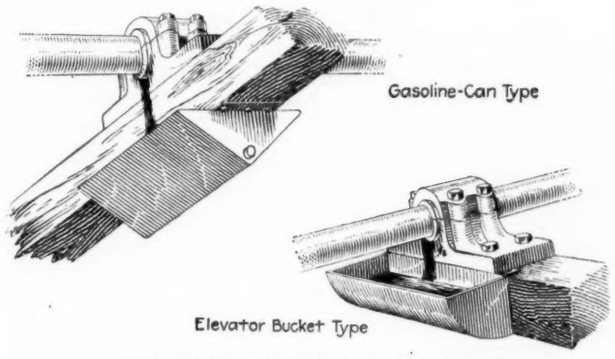
diameter and about 11 rows of holes to the inch. The strainer has four ears to receive the hooks by which it is suspended and is cylindrical in shape. An extra strainer was made for use while the first one was being cleaned. Every two weeks the strainer was removed and allowed to dry until the particles of packing could be easily burned off. This scheme has been tried for six months, but does not give perfect satisfaction as the car still slides, although not so badly as before. It was suggested that two strainers be used, one inside the other.

In my opinion a separate tank should be used where the water is returned from the system and a strainer or a screen used between it and the supply tank. The water would flow quietly through the strainer, and any foreign matter would be easily caught. With the strainer directly under the discharge pipe, however, the force of the water sends the dirt through the hole and into the tank, whence it is pumped back into the system. The system referred to has a pressure of 750 lb. per sq.in. W. T. Osborn.

Newark, N. J.

Shaft Oil-Drip Receptacles

The illustration shows two lineshaft oil-drip receptacles. Of the two the oil-can type, made out of half a five-gallon oil can nailed to the bottom of the timber di-



TWO EASILY MADE OIL CATCHERS

rectly under the line-shaft bearings, is the cheaper. Use is made of the spout to draw off the oil when necessary. The bucket type is easily made where old discarded elevator buckets are obtainable. The oil that accumulates is dipped out and put through a filter.

Denver, Colo. Arthur C. Daman.

Locating Valves with Regard to Pressure

Referring to Mr. Miles' letter on page 698 in the issue of Oct. 24, I have known of an angle valve located with the pressure above the disk, so that the stem could be extended through the floor above. This disk came off one evening about 6 o'clock and shut down the vacuum pump, and as the engine could not carry the load noncondensing, a part of the city was temporarily left in darkness.

Another valve (a Y blowoff), with the pressure below the disk, stripped the worn threads on its stem and emptied the boiler with a hot fire under it. Of course there should have been two valves, and in the other case the disk should have been secured so it could not come off; but in these, as in many others, it was not the case.

The way a valve should be put on depends on what would happen if it failed—which would be worse, to shut an engine down or for the thread to strip when opening a valve to let steam into a cold pipe line. With a ring system of piping no rule can be given.

Blowoff valves, angle or Y type, should have the pressure above the disk. Main boiler stop valves (when two are used) should be set so that when both are closed there will be no pressure on either stuffing-box. There are still some boilers with only one valve; this should be set so that the pressure from the main is above the disk. Harry D. Everett.

Washington, D. C.

Making the Best Use of Fuel

In the editorial, "Making the Best Use of Fuel," in the issue of June 27, 1916, attention was called to the fact that the percentage of B.t.u. in fuel at present wasted was a civic as well as an economic question and a prophecy was made that the time would come when no one would be permitted to throw away three-fourths to nine-tenths of the heat of fuel, as is being done at present. While mention was made only of the heat wasted in the exhaust steam (this being by far the greatest thief of fuel), it was to be inferred that other large losses would also be given serious attention. Chief among these are heat loss in dry chimney gas, incomplete combustion, radiation and preventable friction.

The first-named, representing the sensible heat of the dry chimney gas, constitutes a loss in the average plant of about 21 per cent. of the total B.t.u. in the fuel and is greater than all the others combined with the exception of exhaust steam. The explanation of this large loss is readily understood when one remembers that the temperature of the flue gases in most plants is nearer 600 than 500 deg. F. The percentage of heat wasted in flue gas at these temperatures is 24.5 per cent. and 19.9 per cent. respectively, these figures being based on coal averaging 14,000 B.t.u. per lb., a boiler-room temperature of 70 deg. F. and on using 26 lb. of air per pound of coal, which corresponds to approximately 10½ per cent. of CO_2 in the flue gas. In plants using a greater quantity of air per pound of coal, with the flue gas averaging only 6 or 8 per cent. of CO_2, the percentage of heat lost is much higher.

There is burned annually in the United States something like 250,000,000 tons of coal in stationary power plants, and of this about 52,500,000 tons goes to waste up the chimney to foul the atmosphere. What is more, this coal is either carted to the plant and shoveled into the fire and shoveled out and disposed of as ashes, or there is the expense of installing and operating conveying apparatus, coal bunkers and mechanical stokers. In either event there is about 20 per cent. more wear and tear on the complete equipment than would be the case if no heat was wasted in the flue gases. This loss can be reduced and is being reduced approximately 50 per cent. by a few thousand plants in this country by the use of fuel economizers.

To lessen the percentage of the B.t.u. wasted in the flue gas, the temperature must be lowered in such a way that the heat abstracted will be utilized. This may be accomplished to some extent by the following means singly or by combinations best adapted to given cases: By build-

ing the grate and combustion chamber of proper proportions for the amount of boiler-heating surface and the kind of fuel to be used, with a chimney of sufficient height and area to give the draft required, or by installing mechanical-draft fans which will permit of controlling the draft accurately under all conditions and by keeping the baffles in good repair; by using as near the correct amount of air as possible for the kind of coal burned and the particular plant conditions. It is advisable to have a CO_2 recorder, for while about 18 lb. of air is necessary to burn one pound of coal, in the average plant more than 26 lb. (almost 50 per cent. excess) is often used. Most of the air that enters through holes in the fire and cracks in the setting does not help in combustion, but merely absorbs and carries away heat. Attention to the fires and care in keeping the setting in good repair and the boilers clean are therefore essential. Scale and soot, being great heat insulators, decrease the amount of heat that the boilers abstract from the fuel; and if allowed to accumulate, the flue gas reaches an extremely high temperature.

Attention to the foregoing will probably enable the boiler to reduce the gas temperature to about 500 deg. or less. This still represents a large percentage of the total heat in the fuel, but it does not pay to use more boiler surface, as the heat absorbed per square foot of added surface is worth less than the first cost and the upkeep of the extra heating surface. The gas may profitably be reduced to a lower temperature, however, by an economizer, because of the greater difference in the temperature between the water in the economizer and the flue gas.

From a table giving the results of economizer tests in 26 different plants the average gain will serve to illustrate:

ACTUAL RESULTS OBTAINED BY ECONOMIZERS

Gas Entering Economizer	Gas Leaving Economizer	Water Entering Economizer	Water Leaving Economizer	Temp. Rise of Feed Water
530 deg. F.	343 deg. F.	157 deg. F.	256 deg. F.	99 deg. F.

As a whole the saving by the economizers may be figured as follows, assuming a boiler pressure of 150 lb. gage. Total heat in 1 lb. steam above 32 deg., 1,193.5; feedwater temperature, original 157 deg., final 256 deg.; increase in heat units, 99; heat units above 32 deg. in feed water of original temperature, 125; heat units in steam above that in cold water, 1,193.5 — 125 = 1,068.5; saving in fuel by economizers, 99 ÷ 1,068.5 = 9.26 per cent.

Saving 9.26 per cent. the annual coal consumption (250,000,000) as given, it is apparent that by this means alone 23,150,000 tons could be conserved each year.

New York City. F. J. McMahon.

The Engineer's Compensation

I read the foreword in the issue of Nov. 14 with a great deal of interest. Our friend the engineer seems to have been a man who studied to prepare himself for a higher position and a larger salary, should an opportunity offer, but up to the present it has not arrived. He has, however, taken the right course, although his light seems to have been hidden under a bushel.

In my experience of 40 years I have known of many similar cases. To some the chance comes, but to others, never. To be prepared is a prime essential, for how humiliating it would be to have an offer of a good position and salary and not be qualified to accept it! The engineer's profession is no different from any other—all have to store up knowledge, then get experience. How many lawyers, doctors, chemists, etc., are making a good deal less than our friend the engineer, yet, like him, are capable of greater things. Take for instance a doctor who is subject to call at any time. His income is regulated in a measure by his ability, but more by the amount of advertising he gets from his patients and friends. With the engineer it is different. He gets no advertising from his employer or his friends (engineers). It is only on rare occasions that one will admit that he is a competent man; more often we hear the remark, "I knew when he was firing only a few years ago," etc.

Our trade papers are continually and rightly urging their readers to greater effort to better fit themselves, and all urge a proper compensation. The wage question is one for each individual to settle. A man who has the knowledge and ability of a first-class engineer should be able to go to his employer and talk for what he thinks a just compensation.

Cheaper power is the cry, but it should be obtained from the equipment and not from underpaid employees. The engineer is a necessity, not a luxury, but he must keep on improving. J. C. Schenk.

New York City.

Overcoming Inductance

I read with much interest the article regarding a remedy for the inductance of coils, by Edwin C. Huth, in the Oct. 24 issue of *Power*, page 598.

In my case the inductance was overcome by doing away with the coils entirely in the following manner: The discharge pipe from the dredge was carried to the bank of the pit on pontoons and jointed with flexible connections. A number of these pontoons were held in reserve fully equipped with pipes, and cables were placed on arms above the tops of the pontoons and fitted with quick-connecting couplings. All that was necessary to lengthen the connections to the shore was to place a pontoon next to the dredge and make the electrical connections while the pipes were being joined. This required but a few minutes, as the cable connections were only split bolted lugs each having two ⅜-in. bolts.

I think that the solution advanced by Mr. Huth is inadvisable owing to the fact that there would still be some choking action even if all three wires of the three-phase circuit were wound on the same reel—although theoretically there should be none. The shaft of the reel would provide a core for the choke coil, and if a wooden shaft were substituted, the action would still remain, though to a lesser extent. The choking action would depend on the number of turns in the coils, and this would be governed by the distance it is desired to provide for in the reels, which should be at least 1,000 ft. to be of any value. A reel arranged to wind and unwind a three-conductor cable would be quite complicated to construct, especially if the cable is heavy. By using short lengths of cable, the motor is always operating with a minimum drop in the line. G. C. Long.

Lakeland, Fla.

Heavy (viscous) Oil may fail to distribute evenly in close fitting bearings and allow some parts to become injured while other parts are flooded.

Humane Furnace Stoking

The plea for the more humane treatment of stokers and firemen is silently voiced every day by many who read your recent editorial (Oct. 17 issue) and by thousands who unfortunately are unable to do so. It is to be hoped that it may awaken a realization in those who are in a position to remedy matters, not only on the score of humaneness but also of economy. Circumstances prevent an ideal arrangement of apparatus in many cases, but it is always possible, and generally costs little or nothing, to supply those things which make all the difference between comfort and discomfort for the boiler-room attendants.

It seems extraordinary in these days, when so much attention is being given to the attainment of efficiency, the reduction of lost motion and the needless consumption of foot-pounds of energy, that so little effort is made to conserve that human machine, the fireman, by saving his energy when not needed. After all, the fireman is only a human machine requiring humoring instead of repairs, and money invested in washroom, proper ventilation and light and chairs in which he may recuperate his strength will be found well worth while in every instance.

The fireman's job is at best not an easy one. He must often work hard and monotonously, day after day, under the worst possible conditions, when a little forethought or consideration would materially remedy matters. Many boiler rooms are cheerless, uncomfortable and unhealthy, not of necessity, but because the management does not care. Such policy is short-sighted, selfish as well as unbusinesslike, and reacts to the detriment of all concerned. Space limitations may impose engineering restrictions, but there is no need for lack of consideration in small but important ways. Firemen are not convicts that they should be treated as many of them are. The day will come when they will be properly paid and required to work only under proper conditions.

Many firemen are working under miserable conditions and for miserable pay, when a small increase in wages would attract a better grade of labor and would be well worth while financially. A poorly paid fireman is usually extremely expensive and will waste many times his salary in careless or useless firing either through lack of knowledge or because he does not care. The economy of the boiler room depends to such a large extent upon the personnel that the choice should be carefully made. A fireman is made, not born, and the making requires prolonged, patient and careful training by intelligent persons understanding the man's needs and how to develop his interest. Training takes time, and the value of a fireman increases with his length of service, and his wages should be increased accordingly.

Much has been said of late about the eight-hour day for railroads, but what of the firemen who work ten and often twelve hours at a shift without the luxury of the dinner hour? It is not fair to the man or the boiler room, because a workman's efficiency drops rapidly after eight hours' work. If by knowledge and painstaking a man effects economy and a saving to his employer, who has the most to gain, let him share in the saving.

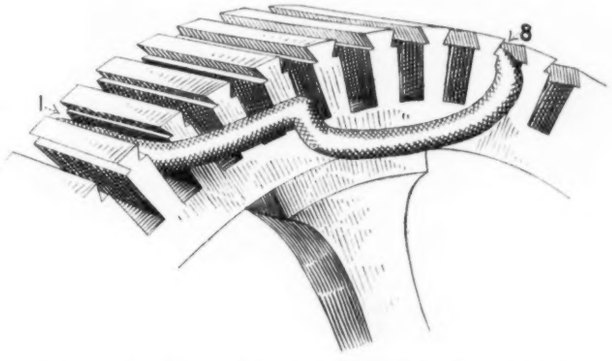
A capable, sober, steady boiler-room attendant is an asset, and while it is not perhaps advisable to advertise the fact too often, it should not be forgotten in paying him his remuneration and in catering to his bare needs. The majority of men will remain where they are well paid and decently treated, even if the work is hard. The frequent changing of boiler-room attendants is a costly business and many companies recognize this as a fact, notably the larger ones, and find it financially advisable to keep their men.

Why should a fireman take an interest in his work if the management does not? In the boiler room the greatest laxity is often allowed to exist, although it is there that the greatest economy may yet be practiced. Perhaps one reason that the boiler room is so often ignored is because it is dark, dirty and uncomfortable. Let there be light and ventilation; give the men those few comforts that are really necessities of life. Give them consideration, and the financial returns will be shown in increased economy, better service and the loyalty of satisfied employees. That these simple and obvious facts have not been heeded by many who are supposedly gifted with keen business acumen is surprising. R. K. Long.

New York City.

The Armature Coils Had Wrong Spread

The spread of an armature coil means the arc included by the coil when it is installed on the core. The spread might be expressed in degrees, but such a designation, while convenient on a drawing board, would be exceedingly awkward for a winder. Accordingly, in actual winding work it is customary to express it in terms of the slots, as follows: If in installing the coil, one of



SECTION OF ARMATURE SHOWING COIL-SPREAD

its sides goes into a slot called No. 1 and the other side goes into slot No. 8, as shown in the figure, the spread of the coil is said to be one and eight. How much of the core the spread of a coil must include depends on the number of field poles; on a four-pole machine the theoretical coil-spread is one quarter of the periphery, on a six-pole machine, one sixth of the periphery, and so on, the total periphery in each case being divided by the number of poles in order to get the coil-spread. The idea is to have the spread the same as the angular distance included between adjacent field centers. In practice the theoretical spread can be only approximately realized, but liberal proportioning of the neutral field amply compensates for well-judged discrepancies.

An operator bought a new armature from the original makers of a four-pole continuous-current motor, to replace one that had given trouble ever since it had been rewound after going through a fire. After operating the

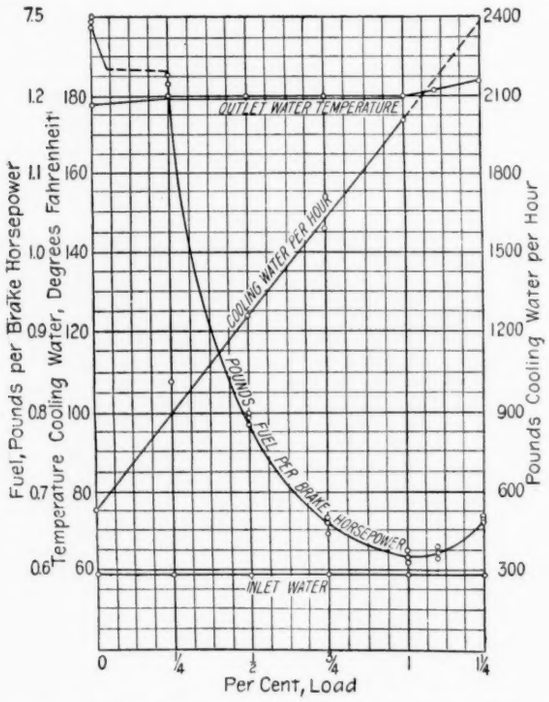
new armature satisfactorily for two months, he became convinced that the trouble of the old one was in the armature itself, so it was returned to the factory for rewinding. The factory found that the core had been rewound with coils that were of the wrong spread, with the result that when the conductors of one side of the coil were in a neutral field, the conductors of the other side were in a very active field; therefore the brushes were at all times short-circuiting coils in which considerable voltage was generated.

How the wrong coils came to be handled could not be determined; it might have been due to an error in ordering the coils or in shipping them. In any event, if the spread of the old coils had been noted before removing and scrapping them, installing the new coils with the same spread would have been impossible, because they were entirely too small. E. C. PARHAM.

Brooklyn, N. Y.

Semi-Diesel Oil-Engine Test

Some time ago I participated in a fuel test on a 14x17 (50-hp.) vertical fuel-oil engine of the semi-Diesel type. The engine uses crank-case compression, air being admitted to the crank case through a light leather flap



FUEL AND WATER USED AT VARIOUS LOADS

valve. The fuel is injected into the combustion chamber by means of a force pump, no air blast being used, and upon striking the top is ignited. The top is separate, forming a hot plate, and is not cooled. There is a pin extending through this hot plate, which is heated by a torch when starting the engine; on the first few charges the oil strikes this red-hot pin, which vaporizes and ignites the oil.

This particular engine was installed in a small mill and light plant, and the question as to the fuel consumption in actual operation was raised. Consequently a test was made, consisting of three one-hour runs at the various loads, and the fuel was carefully weighed. The temperature of the cooling water was maintained as constant as possible by operating the inlet valve, and the amount of water used was measured by means of two tanks of known volume. The engine carried a 10 per cent. overload with ease, but at 25 per cent. overload the exhaust was rather smoky, showing that part of the fuel was not being consumed, and it labored considerably and lost speed slightly. The main bearings ran warm at all loads upward from three-quarters. However, this never became serious, and there is no doubt that the engine could operate at rated load continuously with no real bearing trouble.

The fuel used was a 38-deg. distillate weighing 6.94 lb. per gal. The guaranteed full-load consumption of $\frac{1}{10}$ gal., or 0.694 lb., per brake horsepower at full load was more than fulfilled. The fuel consumption at other loads is shown by the chart. L. H. MORRISON.

Fremont, Neb.

Balancing a Heating System

At this season of the year the attention of many engineers is turned toward heating and its problems. On taking charge of a large heating plant the following program was carried out, and the results were found to be exceedingly gratifying.

A thorough inspection of traps, mud legs, etc., was made; then with all returns open the vacuum pump was started, and with several inches of vacuum on the return line steam was gradually admitted to the line. Enough end traps were opened to permit the vacuum to extend back to the power house in the supply line. Several days were consumed in "warming up" the system, during which time the return lines were kept clear and there was no water-hammer and no leaks. Engine exhaust was then turned in, the live steam shut off and the atmospheric valve closed.

The question of balancing the system now absorbed our attention and proved of extreme interest. The individual return line of each building was provided with a special vacuum equalizer consisting of a water trap below and a vacuum-regulating trap above the main—both returning to the main farther along. Each building is thus served with just the required amount of vacuum to insure its getting its share of steam and also to insure dry return lines. The buildings farthest from the power plant required, in some cases, more than double the vacuum requisite to those near-by. Satisfactory distribution was effected only after a series of observations, and as a result all sections of the return system are kept dry at all times and enough vacuum is maintained upon the common return to provide for the maximum requirement of all branches combined. After the balance was struck, a slight adjustment of the weights on the individual regulators was sufficient to equalize the distribution of the steam over a large area.

Imperfect distribution is the source of much waste as well as imperfect service. EDWARD T. BINNS.

Philadelphia, Penn.

Destructive Distillation, or dry distillation, means heating an organic substance that is not in itself distillable to such a temperature that it is decomposed into other bodies, some of which evaporate and may be condensed. An example of this is the destructive distillation of coal as carried on in the gas works or of wood for the production of wood vinegar.

Inquiries of General Interest

Arresting Pitting of Boiler—What is the best treatment of a boiler to stop pitting? F. M.

Scrape the corroded part clean and coat it with best minium or graphite paint. Then supply the boiler with water treated to the best advantage for neutralizing its corrosive action and make frequent washings and inspections of the boiler to ascertain whether the treatment of the water is beneficial.

Gravity of Fuel Oil No Measure of Calorific Value—What is the formula for determining the B.t.u.'s per pound of a fuel oil from the Baumé reading of its gravity? H. R.

The gravity is by no means an accurate measure of relative calorific value, which should be based upon the percentages of carbon, hydrogen and oxygen as determined by an ultimate analysis, with due allowance for the combination of the oxygen with its equivalent of hydrogen to form water.

Miter Gear Wheel—What is the difference between a miter and a bevel gear? R. D.

A bevel gear wheel is one whose working surfaces are inclined to the axis. When the axes of two bevel gear wheels working together would meet at some point, if produced, the working surfaces form the frusta of two cones whose axes would meet in this point. When the pitch surface of each wheel has a bevel of 45 deg., the wheels are called miter gear wheels, the wheels will be of the same size and their axes will form an angle of 90 deg.

Use of Oil Reclaimed from Oil Separator—What use can be made of the oil gathered by an oil separator in an exhaust-steam heating line? A. K. S.

The oil discharged from a separator in a heating line when gathered and filtered has value as a heavy lubricant and may be used for adding body to lighter machinery oils. But the oil thus recovered should not be depended upon for repeated use as a cylinder oil, as there may be danger that all grit and dirt have not been recovered and, once used in a steam cylinder, the oil may have parted with properties essential to a good cylinder lubricant.

Smoke Uptake and Chimney for Heating Boiler—For a heating boiler that has a grate 27x42 in. for burning pea coal, what should be the diameter of the smoke uptake and the size of the chimney flue if 50 ft. high? A. F.

A good rule for size of smoke uptakes for heating boiler, where the apparatus is governed automatically and fires are attended at long intervals, is to allow a cross-sectional area of uptake equal to one-tenth of the grate area. Accordingly, a heating boiler with a grate 27x42 in., or 1,134 sq.in., should be provided with an uptake pipe having a cross-sectional area of 113.4 sq.in., or practically 12 in. diameter. If a smooth and straight chimney flue 50 ft. high is provided, the least cross-sectional dimension should be 12 in. and, to cover allowances for roughness and want of cleaning, the flue should not be less than 12x16 in.

Testing Leakage of Piston Rings—How can the leakage of an engine's piston rings be tested? H. B.

Place the engine on the head-end dead-center and, with the cylinder head removed, admit steam of the usual initial pressure on the crank side of the piston and any leakage past the piston rings is readily observed. Ordinarily, the leakage of the piston rings when the piston is in the head end of the cylinder may be regarded as fairly representative of leakage at other points in the stroke. Similar tests may be made with the piston standing at other points of the stroke, by securely blocking the engine from turning. It should be borne in mind, however, that an observation of leakage at any point of the stroke should be made with reference to the pressure that would be present when, in regular operation of the engine, the piston is at the same point of the stroke.

Relative Power and Economy of Small Engines—What would be the relative power, and economy with the same load, of a pair of autotruck steam engines 6x7½ in. operated at 300 r.p.m. with a boiler pressure of 250 lb. and a pair of engines 4½x6½ in. operated at 450 r.p.m. with a boiler pressure of 600 lb.? G. B.

At the same point of cutting off and running conditions stated, the indicated power developed by the 6x7½-in. engine would be to that developed by the 4½x6½-in. engine as $(6)^2 \times 7\frac{1}{2} \times 300 \times 250$ to $(4\frac{1}{2})^2 \times 6\frac{1}{2} \times 450 \times 600$, or as 1 to about 1¾. With the same percentage of cylinder clearance and cutoff at the same point, the probable economy would be in favor of the engine operated at the higher piston speed and higher pressure. But the actual relative economy when cutoff in each case is appropriate for a given load cannot be predicted without making actual tests of economy of the engines when so loaded.

To Reduce Baumé Readings to Pounds per Gallon—With the Baumé reading of a fuel oil or distillate known, how is the number of pounds per gallon determined? C. D. C.

The weight per gallon will be equal to the weight of a gallon of pure water multiplied by the specific gravity, or weight, of the liquid as compared with the weight of an equal volume of pure water. One American gallon of pure water at 62 deg. F. weighs 8.3356 lb. and one British gallon weighs 10 lb. To convert degrees Baumé into specific gravity the following formulas are used:

For liquids heavier than water, sp. gr. = 145 ÷ (145 — deg. Bé).

For liquids lighter than water, sp. gr. = 140 ÷ (130 + deg. Bé).

Thus, for an oil that is lighter than water, if the reading per the Baumé hydrometer is 21 deg., then sp. gr. = 145 ÷ (130 — 21) = 0.927, and the weight would be 8.3356 × 0.927 = 7.727 lb. per American gallon (231 cu.in.).

Turning Stripped Side of Belt Away from Pulleys—What would cause pieces to be torn from a 12-in. double leather belt on the side that runs against the pulleys, and would not the life of such a belt be increased by turning the other side toward the pulleys? B. L.

Pieces like surface layers probably became stripped from the pulley side of a belt from the use of a friction dressing or an adhesive that had gathered in lumps on the faces of the pulley, or this may have resulted from doping the face of a pulley to prevent the belt from slipping or from applying too much dressing to the pulley side of the belt. If the opposite face of the belt is smooth and clean, the life of the belt will be prolonged by turning it over, provided the pulley faces are kept clean. If necessary to reduce slippage by use of a dressing, it should be spread thin over the surface of the belt and be of a kind that will not leave the belt and build up on the faces of the pulleys. Lumps of any kind on the faces of the pulleys are likely to cause stripping of the belt surface and should be removed at the first opportunity.

Color Scheme for Piping—What colors of paint are suitable for different pipe lines, such as for fire protection, high- and low-pressure water and steam lines of manufacturing and power plants? O. H. C.

For identification of the different systems it is common practice to employ the primary pigment colors, red for fire lines, yellow for steam lines and blue for water lines, using the deepest shades of those colors for primary lines and lighter shades or tints for branches and return lines. The color scheme used in some of the systems of piping of a New York City building (given p. 445, Mar. 31, 1914, issue of "Power") is as follows:

Fire Protection Piping (Red)—Fire line, vermilion; sprinkler main, venetian red; sprinkler dead riser, crimson lake.

Water Pipes (Blue)—Cold water, cobalt blue; drinking water, prussian blue; drinking-water return, ultramarine; hot water, emerald green; hot-water return, Hooker's green.

Steam Pipes (Yellow)—High-pressure steam, deep orange chrome; high-pressure drips, orange chrome, pale; medium-pressure steam, chrome yellow, medium; low-pressure drips, chrome yellow, pale; exhaust steam, yellow ocher.

Heating Pipes—Heating mains, olive green; feed lines, apple green; returns, chrome green.

Refrigeration Pipes—Brine pipes, cobalt blue and white; ammonia, violet.

Boiler Blowoff—Claret.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Utilization of Waste Heat for Steam Generation*

SYNOPSIS—Deals with the principles underlying the utilization of waste heat for steam generation and gives a general survey of what has been done in this field.

The design of waste-heat boilers has progressed to a point where it is today possible to generate steam successfully from gases whose temperatures are as low as 950 or 1,000 deg. F[1]. It is but a few years since it was considered impracticable from a commercial standpoint to attempt to produce power from such gases, and it is in its ability to satisfactorily utilize these gases that the development of the modern waste-heat boiler has its most far reaching effect.

The rate of heat transfer is dependent upon gas velocity and temperature difference between the gas and the absorbing surface. Experiments have shown that at even the highest velocities now used in waste-heat work the effect of increased temperature difference is small as compared with that of increased gas velocity.

In coal-fired boiler practice, the average temperature difference between gases and boiler surfaces is approximately 1,150 deg. The heat-transfer rate corresponding to a boiler's rated capacity is about 3 B.t.u. per hr. per sq.ft. of surface per degree difference, or a heat absorption of 3,450 B.t.u. per sq.ft. of surface per hour. In waste-heat work the temperature difference varies widely with the class of waste heat. With a gas temperature, say, of 1,250 deg. entering a boiler, the average temperature difference between boiler surface and gas for a working pressure of 170 lb. per sq.in. will be about 500 deg. For such a temperature difference the transfer rate, to give an absorption per square foot of surface equal to that of the coal-fired boiler at rating, would have to be 6.9 B.t.u. per hr. per sq.ft. per deg. difference. This rate is slightly higher than the rates corresponding to velocities that are as yet ordinarily used, but with somewhat higher entering gas temperatures, the absorption per square foot of surface is such as to enable a boiler's rated capacity to be developed without difficulty. With gas temperatures entering the boiler of 1,800 to 2,000 deg., which approach the temperature of coal-fired furnaces, high overloads are being developed in practice.

The gas velocities necessary to give what is now considered a desirable transfer rate led to a frictional resistance through waste-heat boilers which makes the use of a natural-draft stack impracticable. Let us consider what is probably the extreme case in so far as draft conditions are concerned; namely, the openhearth steel furnace. Common practice in this class of work is to use stacks 160 ft. high, which give a draft at their base approximately 1.4 to 1.6 in., depending upon the gas temperatures. For the present purpose assume that the draft loss through a modern waste-heat boiler installed with an openhearth furnace is 2.0 in., a figure that approximately represents the practice of today. With a natural-draft stack, the draft at the checkers corresponding to the 1.4 to 1.6 in. given is approximately 1.3 to 1.5 in., and this amount is necessary for the proper operation of the furnace. With a waste-heat boiler installed, then, the draft necessary at the exit of the boiler must be sufficient to overcome the resistance through the boiler, 2 in., that necessary to overcome resistance through the flues, say 0.75 in., and 1.5 in. necessary at the checkers, or a total of 4.25 in. It is to be remembered that with a waste-heat boiler installed, the temperature of the gases entering the stack, instead of being 1,000 or 1,200 deg., will be 450 or 500 deg., under which conditions a stack of 160 ft., instead of giving a draft of 1.4 to 1.6 in. at its base, would give approximately 0.9 in., and to give the necessary 1.25 in. the stack height would have to be somewhat over 700 ft.

While, as stated, this is perhaps the extreme case, the same reasoning applies in practically all waste-heat work, and an induced-draft unit is now almost universally used with the modern design of waste-heat boiler.

The waste-heat boiler of today was developed with low-temperature gases, and its largest field has been with openhearth steel furnaces.

From the very nature of the operation of the openhearth steel furnace, gas temperatures passing to the stack are low, and the ability of the modern waste-heat boiler to utilize successfully these gases for the generation of steam is the best proof of the progress in the development of this particular class of boiler.

C. J. Bacon, steam engineer of the Illinois Steel Co., presented before the American Iron and Steel Institute in May, 1915, a paper, "Waste-Heat Boilers for Openhearth Furnaces," in which he describes an experimental boiler and traces the development in this class of work through three installations.

The third installation described is that made at the Pencoyd Works of the American Bridge Co. and consists of a cross-drum Babcock & Wilcox boiler, the width of boiler and the tube length being such as to give the gas-passage areas necessary for the required gas velocity. For low-temperature waste-heat work, the type of boiler of which this installation is an example is in general best suited.

Table 1 gives the results secured from the Stirling and Rust boilers described and from Babcock & Wilcox boilers similar in design to that installed at Pencoyd, though set with considerably larger openhearth furnaces.

Tests 1, 2 and 3 are as given in Bacon's paper and its discussion. Test 4 is included as being of interest in indicating the results that may be secured with gases at a temperature considerably below that ordinarily found in openhearth work.

TABLE 1. RESULTS OF TESTS OF WASTE-HEAT BOILERS FOR OPEN HEARTH FURNACES

Test number	1[1]	2	3	4
Plant	Illinois Steel Co.	Indiana Steel Co.	Bethlehem Steel Co.	Lackawanna Steel Co.
Location	S. Chicago, Ill.	Gary, Ind.	S. Bethlehem, Pa.	Buffalo, N. Y.
Rated capacity of furnace, tons	65	75	80	[5]
Actual production, tons	72[2]	85	82.6	.....
Boiler	Stirling	Rust	B. & W.	B. & W.
Heating surface, sq.ft.	4,000	4,880	5,232	5,407
Superheat, deg. F.	128	176	121	97
Gas weight, lb. per hr.	73,000	83,434	75,271	78,947
Gas per hr. per sq.ft. of h.s., lb.	18.3	17.1	14.4	14.6
Temperatures:				
Gas entering boiler, deg. F.	1,227	1,155	1,362	986
Gas leaving boiler, deg. F.	621	530	493	468
Drop in temp., deg. F.	606	625	869	518
Draft at boiler inlet, in.	.....	1.47	1.55	1.76
Draft at boiler damper, in.	.....	3.95	3.29	3.63
Draft loss, in.	1.78	2.48	1.74	1.87
Gross hp. developed	334.5	393	425.8	306
Per cent. of rated capacity[6]	83.6	80.6	81.4	56.7
Boiler hp. to fan	[3]	60[4]	24.3[3]	.....
Net horsepower	.....	386	401.5	.....
Approximate transfer rate (R)	5.08	6.92	4.77	5.12

[1] Average of ten tests. [2] Approximate. [3] Motor-driven fan. [4] 53 hp. returned in feed-water heater. [5] Tilting furnace. [6] All ratings are on the basis of 10 sq.ft. per hp.

In Table 1, as in the other tables, the proper basis for the comparison of results is the rate of heat transfer, but that such a comparison may be intelligent, it is necessary in connection with the transfer rates to give proper consideration to the gas weights per square foot of heating surface, entering and exit gas temperatures, and the percentage of rated capacity developed. To give a direct comparison of the performance of two different boilers, the gas weight per square foot of heating surface and the entering gas temperature should be the same.

It is possible from our present knowledge of the laws of heat transfer to compute with surprising accuracy the results that may be expected from any boiler for a given set of conditions. Let us consider, then, the results which the boiler of Test No. 4 would give under the gas conditions of Test No. 1. For a weight of gas per square foot of surface corresponding to Test No. 1, the total weight of Test No. 4 would become 98,950 lb. per hr.

With this weight passing through the boiler of Test No. 4, at the temperature existing in No. 4, the boiler would develop approximately 363 hp., or 67 per cent. of its rated capacity. With an entering temperature equal to that in Test No. 1, the boiler would develop approximately 500 hp., or 92 per cent. of its rated capacity. These figures are included simply to show the importance of giving all factors proper consideration where a comparison of results is to be made of capacity performances.

It is recommended, and today this recommendation is being more or less followed, that the boiler be placed central with the furnace and the bypass stack on the branch connection. Such an arrangement will give a straight gas passage to the boiler, minimizing frictional resistance in the

*Read at the annual meeting, December, 1916, of the American Society of Mechanical Engineers, New York.

[1] All temperatures herein given are in deg. F.

connecting flues, and will have a tendency to give an equal distribution of the gases across the width of the boiler.

A further advantage of such an arrangement is that better protection against the high temperature is given to the bypass stack damper.

Ordinarily flues from the reversing valves to the boiler are placed underground, and their depth beneath the surface should be such as to furnish a sufficiently thick insulating layer of earth on top, from say three to four feet. Ample means should be supplied for keeping these connecting flues clean, and the area should be such as to allow a certain amount of accumulation of dust when the furnace is down without impeding the draft.

The results of the two runs (120 hr. each) showing the effect of reducing air leakage, are as follows:

	Run No. 1	Run No. 2
Gas entering boiler { CO_2	8.08	10.49
Gas entering boiler { O	11.46	8.29
Gas temperature entering boiler	855	1,153
Gas temperature leaving boiler	426	479
Draft boiler damper	3.99	3.77
Draft boiler inlet	1.85	1.85
Draft drop	2.14	1.92
Steam to fan engine (in terms of boiler horsepower)	35.7	28.1
Horsepower developed	132.4	200.2
Per cent. of rated capacity	53.8	81.4

In practically all plants now operating waste-heat boilers in connection with openhearth furnaces, the boilers are dusted once in 24 hr. In one plant which operates 11 such boilers and in which the results are closely checked, the engineers dust every 8-hr. shift.

In the operation of openhearth furnaces certain characteristic explosions are liable to occur during the reversal of gas valves. These vary in intensity from slight puffs to rather heavy explosions and are caused by a mixture of fresh air with carbon monoxide, which must pass off during the operation of reversal. Such explosions, often unnoticed with furnaces directly connected to a stack, become very evident where boilers are installed, and every effort is made to keep flues and settings tight. For this reason particular attention should be given to proper buckstay construction and an ample number of explosion doors should be furnished to relieve the pressure within the setting should explosions take place. By a proper system of reversing valve operation the difficulty would be practically overcome—certainly to an extent where sufficient and properly designed explosion doors would obviate the possibility of wrecking or injuring the settings.

Table 2 gives results of tests of waste-heat boilers for cement kilns.

TABLE 2. RESULTS OF TESTS OF WASTE-HEAT BOILERS FOR CEMENT KILNS

Test number	1	2[1]	3[1]	4
Plant	Cayuga Lake Cem. Co.	Sandusky Port. Cem. Co.	Burt Port. Cem. Co.	Louisville Cem. Co.
Location	Ithaca, N.Y.	Dixon, Ill.	Bellevue, Mich.	Speeds, Ind.
Size of kilns, ft	.....	8 × 100	7 × 60	10 × 150
No. of kilns connected to boiler	2	1	2	2
Boiler	Wickes	Stirling	Stirling	B. & W.
Heating surface, sq.ft	3,065	3,200	3,200	15,330
Gas weight, lb. per hr	37,749	52,300	53,000	183,700
Gas per hr. per sq.ft. of h.s., lb.	12.6	16.3	16.6	12.0
Temperatures:				
Gas entering boiler, deg. F.	1,800[2]	1,300	1,400	1,400
Gas leaving boiler, deg. F.	660	600	700	423
Drop in temp., deg. F.	1,140	700	700	977
Draft at boiler damper, in.	1.2[3]	0.45	0.30	6.63
Draft at boiler inlet, in.	.....	0.06	0.03	0.81
Draft loss, in	.....	0.39	0.27	5.82
Gross hp. developed	264	275	278	1,346
Per cent. of rated capacity	88	85.9	86	88
Approximate transfer rate (R)	3.19	4.85	4.19	6.01

[1] Results very approximate. [2] Optical pyrometer. [3] Draft at economizer outlet.

In a plant where this system [described in the original paper] was followed, explosions were reduced from approximately 40 per day (about one each two reversals), varying in intensity, to 4 in 411 consecutive reversals covering a period of five days, and of these 4 but 2 could be called heavy and were directly traceable to a leak in a hydraulic valve which, through the operation of the ram, caused the gas valve to unseat.

From another aspect: A conservative estimate of the power delivered by the boilers in this class of work through a year's operation would be 60 per cent. of their rated capacity, or 54,000 hp. The value of a boiler horsepower in a steel mill varies widely with any number of factors, and ranges from $35 to $50 per year. On the basis of the lower figure, which is certainly conservative, the value of the 54,000 hp. produced would represent a saving of $1,890,000. The financial advantages are seen to be appreciable.

Waste-heat boilers, because of their special design, are more expensive than coal-fired boilers.

Strictly speaking, the use of waste-heat boilers in the cement industry is not new. The number of installations, however, has been extremely small. Several attempts were made to utilize the heat in these gases through economizers, but such a small proportion of the total heat was reclaimed in this way and so much difficulty developed through the choking up of the economizers with dust that such attempts were soon abandoned.

In 1915 the first installation of the modern design of waste-heat boiler with rotary cement kilns was made. This was at the plant of the Louisville Cement Co., Speeds, Ind. It consisted of a Babcock & Wilcox boiler containing 15,300 sq.ft. of heating surface and 1,382 sq.ft. of super-heating surface. This boiler is connected to two kilns 10 ft. diameter by 150 ft. long. The nominal capacity of each of these kilns was considered at the time of the boiler installation approximately 875 bbl. per day, but with improved kiln operation, and because of the ability to remove the products of combustion from the kilns through the installation of the induced-draft fan, this capacity has reached an actual output of 1,300 bbl. of cement per kiln per day.

No difficulty has been experienced in keeping the boilers in this service externally clean. Where steam is used, it is perhaps well that this be superheated to minimize the possibility of wetting this dust. At the Burt plant the practice is to dust with air every 12 hr. During dusting periods the bypass damper to the stack is partly opened to reduce the draft at the boiler damper, with the object of setting as much dust as possible within the setting and connecting flue.

BOILERS FREQUENTLY DUSTED

At the Sandusky plant the boilers are dusted with air every 6 hr. Here the boiler is not bypassed when dusting, and a considerable amount of dust is blown up the stack at such times. One of the boilers at Sandusky has been equipped with stationary blowers. At the Louisville Cement Co. plant, the boiler is dusted with superheated steam every 12 hr.

At the Burt plant approximately 60 per cent. of the total steam requirements is furnished by the four waste-heat boilers. The possibilities of saving in this work through the use of waste-heat boilers are most clearly shown by the results secured at Louisville. Here the boiler is of the most modern design and actual coal figures are available before and after the boiler installation.

In 1914, before the installation of the waste-heat boiler, the average coal consumption per barrel of cement for the total plant output was 191.2 lb., of which 99.5 lb. was burned in the kilns and 91.7 lb. in the power house.

The total coal consumption for the 1915 operation was 162.3 lb. per bbl. of cement, of which 104.7 lb. were burned in the kilns and 57.6 lb. in the power house. For March and April, 1916, the total coal consumption was 150.9 lb. per bbl., 104.05 lb. being burned in the kilns and 46.85 lb. in the power house.

At the Burt plant, where the boilers are dusted once in 24 hr., approximately 2,000 lb. of dust is reclaimed from each boiler setting per day and about 8,000 lb. from the flues connecting two kilns to one boiler. This represents about 3 per cent. of the total output of the kiln.

At the Sandusky plant, where the flue arrangement is not such as to give as good a settling action as at the Burt, about 4,000 lb. is reclaimed from the boiler setting and connecting brickwork per day, or 1¼ per cent. of the total output.

The amount of reclamation at the Louisville plant is such as to have reduced the raw material fed to the kilns per barrel of cement from 610 to 586 lb., a saving due to the dust collected of 3.9 per cent.

The Anaconda Copper Mining Co. purchased, in 1903, eight Stirling boilers, rated at the time at 375 hp. each, for installation with reverberatory smelting furnaces. These boilers were not equipped with firing fronts or grates, but were erected with the standard baffle arrangement. As soon as they were put into service it was found that the resistance to the gas flow through the boiler was so great as to affect appreciably the operation of the furnace. It was found, however, that by removing all baffles, the gases passed through the tubes without undue restriction and that there was no interference with the operation of the smelting furnace.

The temperature of the gases entering the boiler averaged approximately 2,200 deg. After the removal of the baffles, it was found that the temperature leaving the boiler was considerably in excess of 1,000 deg., and to diminish this and utilize a greater proportion of the heat, a second boiler, rated at 300 hp., also without baffles, was placed in the rear of the first boiler; that is, the two were set in tandem.

In 1905 or 1906, an installation was made at the Cananea Copper Co., which differed in general arrangement from what was the common practice at the time, as previously de-

scribed, and was a step in the direction of the more modern design of waste-heat boilers. Here, instead of using single boilers or boilers in tandem, three Stirling boilers rated at 314 hp. each were set in parallel, the gases from a single reverberatory being divided and passed simultaneously through all the boilers. With this arrangement each boiler was handling what might be considered a normal amount of gas at an entering temperature approaching that of coal-fired practice, and under such conditions baffle openings could approximate those standard in coal-fired work without excessive draft loss or interference with furnace operation.

The practice at the Cananea plant is described in a paper entitled "Experiments in Reverberatory Practice at Cananea, Mexico," presented in 1909 before the Institute of Mining and Metallurgy, London, by Dr. L. D. Ricketts.

Difficulties were experienced at Cananea through the clogging of the economizers with dust. This interfered seriously with the draft and hence with the furnace operation. Since mechanical draft was not used in this branch of waste-heat work, the designers of the plant omitted economizers in later installations.

As opposed to the continuous operation of a copper-smelting furnace, refining furnaces have a distinct cycle of operation, the gas weights available and gas temperatures varying widely at different periods in this cycle. These temperatures, over a complete cycle, will vary from about 400 deg. during charging to something over 2,000 deg. while melting, and the average for such a cycle, some 30 hr., will be approximately 1,400 deg.

As far as is known, there has been but one attempt made to utilize the theory of high gas velocity in the production of steam from copper-furnace waste gases. This was done in 1914 at the plant of the Raritan Copper Co., Perth Amboy, N. J. This company purchased three 450-hp. Babcock & Wilcox waste-heat boilers of the general design described in connection with openhearth steel furnace practice, a design necessitating the use of an induced-draft fan for the proper operation of the primary furnace. The company has also 2,600 hp. of Stirling boilers in which the principle of high gas velocity is not used, and results from the two designs are available. These results are given in Table 4.

TABLE 4. RESULTS OF TESTS OF WASTE-HEAT BOILERS WITH COPPER FURNACES

Test number	1	2	3	4	5
Plant	Anaconda Copper Mining Co.		Inspiration Copper Co.	Raritan Copper Co.	
Location	Anaconda, Mont.		Miami, Ariz.	Perth Amboy, N. J.	
Furnace	Matte	Matte	Matte	Refining	Refining
Boiler	Stirling	Stirling	Stirling	Stirling	B. & W.
Heatingsurface,sq.ft.	7,500[1]	7,500[1]	14,060[8]	3,940	4,490
Gas weight, lb. per hr.	49,950[2]	98,400[5]	160,010	70,100	50,400
Gas per hr. per sq.ft. of h.s., lb.	6.66	13.13	11.38	17.79	11.23
Temperatures:					
Gas entering boiler, deg. F.	2,200	2,200	1,621	1,429	1,547
Gas leaving boiler, deg. F.	680[3]	890[6]	696	670	584
Drop in temp., deg. F.	1,520	1,310	925	759	963
Draft at boiler damper, in.	.....	.....	0.80	1.15	2.28
Draft at boiler inlet, in.	.....	.....	0.44	0.56	0.60
Draft loss, in.	.....	.....	0.36	0.59	1.68
Horsepower developed.	570[4]	970[7]	1,111	401	365
Per cent. of rated capacity	76	129	78.8	103	81.4
Approximate transfer rate (R)	2.3	3.6	3.4	4.9	4.0

[1] Two boilers in tandem, approximately as A, Fig. 5. [2] Gas from one furnace passing through two boilers. [3] Range, 620 to 720 deg. [4] Front boiler, 470 hp.; rear boiler, 100 hp. [5] Gas from two furnaces passing through two boilers. [6] Range, 800 to 950 deg. [7] Front boiler, 776 hp.; rear boiler, 194 hp. [8] Two single boilers, approximately as B, Fig. 5. Boilers equipped with superheaters in exit flues. Horsepower includes superheat; exit temperatures are after leaving superheaters.

In Table 5 are given some results of tests of waste heat boilers for beehive coke ovens.

TABLE 5. RESULTS OF TESTS OF WASTE-HEAT BOILERS FOR BEEHIVE COKE OVENS

Test number	1	2	3	4
Plant	Priestman Col., Ltd.,	Frick Coal & Coke Co.	.....	.....
Location	Newcastle-on-Tyne	York Run, Pa.	.....	.....
Boiler	Stirling	Stirling[1]	B. & W.	B. & W.
Heating surface, sq.ft.	1,610	10,800	10,200	10,200
Gas weight, lb. per hr.	23,200	83,650	125,500	155,100
Gas per hr. per sq.ft. of h.s., lb.	14.4	7.7	12.2	15.2
Temperatures:				
Gas entering boiler, deg. F.	1,720[2]	1,804	2,329	2,158
Gas leaving boiler, deg. F.	650	490	463	477
Drop in temp., deg. F.	1,070	1,314	1,866	1,681
Draft at boiler damper, in.	0.56	0.56	4.0	4.4
Draft at boiler inlet, in.	0.24	0.30	1.9	2.0
Draft loss, in.	0.32	0.26	2.1	2.4
Horsepower developed.	187	824	1,756	1,956
Per cent. of rated capacity.	116	76	172	192
Approximate transfer rate (R)	4.7	3.2	5.6	6.8

[1] Three boilers, each of 3,600 sq.ft. heating surface. [2] Temperature leaving ovens 1,970 deg. F.

Results of tests of waste-heat boilers for steel furnaces are shown in Table 6.

TABLE 6. RESULTS OF TESTS OF WASTE-HEAT BOILERS WITH STEEL FURNACES

Test number	1	2	3[3]	4[3]	5[3]
Plant	Penn. Bolt and Nut Co.	Cambria Steel Co.	Bethlehem Steel Co.		
Location	Lebanon, Pa.	Johnstown, Pa.	So Bethlehem, Pa.		
Furnace	Puddling	Heating	Structural Mill	Reheating	Furnace
Boiler	3-pass B. & W.	Single-pass B. & W.	B. & W.	B. & W.	B. & W.
Heatingsurface,sq.ft.	1,196	2,998	5,840	5,840	5,840
Gas weight, lb. per hr.	....	16,150	87,571	63,932	80,757
Gas per hour per sq.ft. of h.s., lb.	....	5.4	15	11	13.8
Temperatures:					
Gas entering boiler, deg. F.	....	1,990[1]	1,745	1,071	1,445
Gas leaving boiler, deg. F.	542	729[2]	436	401	418
Drop in temp., deg. F.	....	1,261	1,309	670	1,027
Draft at boiler damper, in.	0.32	0.23	1.87	1.15	1.50
Draft at boiler inlet, in.	....	0.19	0.68	0.39	0.54
Draft loss, in.	....	0.04	1.19	0.76	0.96
Horsepower developed.	73.2	152.8	784.1	326	542
Per cent. rated capacity	61	50.9	134	56	93
Approximate transfer rate (R)	....	1.7	6.1	5.0	5.4

[1] Optical pyrometer. [2] Varied at different periods of furnace operation from 604 deg. to 920 deg. [3] Tests 3, 4 and 5 on same boiler. No. 3 represents 12-hr. period during which the structural mill was in operation, No. 4 a 12-hr. period with the mill not operating, and No. 5 a continuous run of 104 hr. during which the mill operated 56 hr. and was not in service 48 hr.

The writer has knowledge of over 11,000 hp. of waste-heat boilers set in connection with and utilizing waste gases from zinc furnaces. The temperatures in this class of work are high, being ordinarily in excess of 2,000 deg. with certain designs of furnaces and probably averaging well over 1,700 deg. with all classes.

The International Nickel Co. (Orford Copper Works) has in service over 3,000 hp. of waste-heat boilers set in connection with nickel-refining furnaces. As in the case of zinc furnaces, the temperature of the waste gases is high. No complete test figures are available, but from data at hand the boilers are developing over 90 per cent. of their rated capacity with exit-gas temperatures of about 600 deg.

Seeking a Standard Test for Gasoline

A statement has been issued by the United States Bureau of Standards with the object of removing any existing impression that the bureau would formulate a test which might be applied by any purchasers to detect at once an inferior gasoline. "No such simple test is known in the present state of the science of petroleum technology," the bureau states. "In the early days of the petroleum industry, when all our gasolines, kerosenes, fuel oils and lubricating oils were derived from one source—Pennsylvania crude petroleum—a simple measurement of the specific gravity, or what amounts to the same thing, the Baumé number, by means of a hydrometer, served as a fairly reliable indication of the qualities of these products. Today, however, the specific-gravity test is practically worthless as a check on the suitability of a gasoline, for example, for a given motor equipment." In giving the reason for this change and discussing present conditions, the bureau states:

Many new oil fields that have been opened up in recent years yield petroleums of very different physical and chemical properties, and new methods of manufacture have been introduced that yield products having very different properties in no way related to the specific gravities. The problem is an extremely complicated one and presupposes a definition of gasoline. It is highly probable that the specification or definition of standard gasoline and the tests that will be necessary to determine whether the gasoline complies with the specifications will be quite complicated and will require the services of a trained chemist to make them. It seems most probable that the definition of gasoline will have to be based on the percentage that distills over between specified temperatures, when the distillation is carried out under specified conditions. This distillation test, speaking in nontechnical terms, is a measure of the freedom with which the gasoline will vaporize. The gasoline must not vaporize too freely, for two reasons—one that it would not be safe, and, secondly, its loss in storage by evaporation would be too great. Hence, the specification may have to contain limitations of the percentage distilling over below a certain temperature, coupled, perhaps, with a proviso that certain percentages shall distill over below other fixed temperatures, in order that requisite amounts of low-boiling constituents shall be present to insure easy starting of an engine. Likewise the specification must contain a provision that all must distill over below a certain maximum temperature in order to exclude from the gasoline the heavier petroleum distillates, such as kerosene.

Enough has been said to show that no simple tests can be used to fix the composition of such complex mixtures of hydrocarbons as are represented by gasolines. The popular opinion that specific gravity (or degrees Baumé) will suffice

as a test for gasoline is unfortunately erroneous. For example, a gasoline of 70 deg. Baumé from some oil fields is no more volatile than a gasoline of 65-deg. Baumé from other oil fields. Another point about which there is often a misunderstanding is the relative efficiency of high- and low-density gasolines. It is the common opinion of users that gasoline of low specific gravity (or high Baumé reading) is more efficient in that they can get more miles out of a gallon. This is not true if the motor equipment is adapted to the fuel used.

The message which it is particularly desired to convey is that the public should not expect hasty action. It is extremely important that we proceed with the greatest caution and in the light of the fullest technical information. There is only one way, or at most a very few ways, of doing the right thing, while there is an infinite number of ways of doing the wrong thing. A mistake of any kind, such as a specification that is unnecessarily restricted and which might unduly limit competition, will disturb economic and manufacturing conditions and might only result in imposing greater burdens on the consuming public.

The question that very naturally arises at this point is—with such a complicated specification for gasoline, for which the user cannot make the necessary tests—how it will be possible to protect his interests and to assure himself that he is actually getting standard gasoline. The answer is, he cannot possibly do so; the Government—national, state or municipal—must protect him by a suitable inspection service, just as it protects him in matters relating to weights and measures, pure foods, etc. National legislation relating to interstate commerce, making it unlawful to sell a product under the name of "gasoline" that does not come within the specifications, with a suitable inspection service, would be an important contributing factor in safeguarding the consumer's interests. Other products, which might be just as good motor fuels for motor and carburetor equipments adapted to them, could not then be sold in interstate commerce under the name of "gasoline," but would have to be called motor fuels or by some other name that would distinguish them from the standard "gasoline."—"Commerce Reports."

American Uniform Boiler Code Congress

Under the auspices of the Industrial Commission of Ohio, which is the body having charge of boiler regulation in that state, there was held at Washington, D. C., on Monday and Tuesday, Dec. 4 and 5, a congress in the interest of uniform boiler codes, to which the governors of 28 different states sent representatives and which, with the representatives of boiler-making, boiler insurance and other interests, numbered some 70-odd attendants. Hon. J. C. Callery, chief deputy, Division of Boiler Inspection, State of Ohio, presided.

The congress included one lady delegate, Mrs. Helen Adelaide Goldsmith, of Chicago, appointed by the mayor.

The program began with an address by Hon. T. J. Duffy, member of the Industrial Commission of Ohio, who brought out forcibly the obligation of the Government to guard its citizens against the avoidable hazards of industry, pre-eminent of which is the use of magazines of energy like steam boilers, and the desirability of uniformity in the regulations adopted to this end.

He was followed by Dr. F. R. Hutton, professor emeritus at Columbia University and vice-president of the American Museum of Safety, whose topic was "Civilization and Government Are Based on Human Life; Protection of Life Is a Government's First Duty." Professor Hutton's address was as follows:

It would seem that one who on the one hand is permitted to speak for the profession of the mechanical engineer, and on the other hand for the philosophy of attaining safety in industry and in the ordinary avocations of life, has a special privilege. In such a distinguished assembly as a congress to discuss the advantages of uniform standards of legislation as respects boiler construction and operation, he should be able to strike one of the keynotes of such a conference. For the mechanical engineer may claim to represent before you the combination of scientist and professional man and craftsman, conversant with the problem of the design of pressure-resisting vessels. By his tests in the laboratory, by his experience in design and in the field, by his study and deductions from the known facts, he is qualified to know and to understand the forces which are imprisoned in such reservoirs of energy. He knows the properties of the materials which enter into the construction of such vessels and which must be depended on to restrain such forces. He knows the shop processes of fabrication and assembly which make into a complete whole the separate elements of such a structure.

In the second place, the mechanical engineer alone can pass upon the relative weight to be given to claims and argument based upon commercial advantage or opposition to conclusions put forward for special constructions. If, after full and free discussion, a consensus has been reached in conferences of the parties interested, the formulation of such agreement can be trusted as being a safe and sane guide to follow as respects material design and construction of pressure-resisting vessels.

But now in the third place, the mechanical engineer is the ultimate authority in a second great field of the question under discussion, and that is the management, care and upkeep of pressure vessels. Here he is concededly the specialist, both as scientific man and as craftsman in touch with details. He knows the stresses set up in service from the heat of the fire and from the cold and the impurity of the available water. His recommendations may safely be trusted; and so far as these have been made a matter of record in a code of recommendations by the representative organization of such engineers, a gifted and clear-vision speaker will later make clear.

May I then pass quickly to a second phase of my allotted topic and ask you to consider how the mechanical engineer who is also a student of the problem of design and operation as related to safety from accident will view the matter of adequate legislation to prevent such accident from a failure of a pressure vessel? If he has lifted his eyes from drawing board and specifications to see the economic significance of protecting his property, his workfolk and the community which lives around his power plant, he has become a leader whom you cannot afford to disregard. I am not here to wave a banner with a slogan on it, as if no other consideration but that of "safety first" was to receive a proper weight. But I do and must stand for the proposition that an industrial accident—and a boiler rupture or failure is such an accident—is an economic loss and an indefensible blunder from which the community has a right to be defended, and by ordinance or legislation.

A boiler accident entails a loss in at least five directions: First, the property loss in making repairs, otherwise unnecessary. Second, the cost of compensation properly payable directly to the persons injured or spent in insurance premiums. Third, the loss of wages, borne both by the victims and by dependents upon them, and appearing as lost opportunities for schooling and in lowered standards of living. Fourth, and most consequential of all, the loss in arrested production. Every tool and every employee should be making product every working hour, to pay the costs of interest and overhead expense; this earning should be as nearly as possible a continuous process; the cost accounts are such; so that to arrest the earning of either tool or man is to increase the high cost of living. Fifth, the costs borne indirectly but none the less really by the community in the operation of hospitals for the injured, dispensaries, ambulances and premature pensions.

Has the foregoing discussion made it clear that the next and final step of my argument is a logical and necessary one, as stated in the title and topic allotted to me? Is the safeguarding of human life against boiler accident by legislation and ordinance a defensible direction for progress and development? The first step was to show that scientific knowledge and the record of it had advanced to a point where safety could be attained and relied on; the second step was to show that safety and immunity from boiler accident was of significance to enough people to take it out of the narrow limits of a class interest. There remains only the question, Is the result properly attainable through legislative channels?

I claim that it is; and that the thesis of my title can be upheld without incurring any charge of undue paternalism or of socialistic taint. My argument is twofold: First, that complete individualism must break down in a dense population of many persons living on a restricted area of ground; and secondly, that a truth or law that can be shown to apply at one point of a curve of tendencies can be safely applied at other points.

Our forefathers were individualists. They came to this blessed land of individual freedom to escape various tyrannies material and spiritual, and personal liberty was their watchword. In those early days each man digged his own well for his water-supply and provided his own outfall for his sewage as an individual. He made and repaired his own road in front of his holding; he bought his own poisons and stored his explosives and combustibles as he would; he quarantined himself in case of contagious disease; he carried his own and his neighbor's mail. Then he drove his own equipage to town on errands of business or pleasure, or he walked afoot. He made his own wage bargains with his individual employer. Individualism produced great and strong men; but it breaks down under the stress of numbers. The supply of water adequate and protected from contamination must be a corporational affair and probably municipal, and no longer an individual responsibility; the sewage has become too great in quantity to be an uncontrolled factor in the public interest; transportation is too immense a problem to be handled except with a regard to the majority interests; and the method of collective bargaining in wage problems is forced to the front when the number of earners in one plant exceeds a thousand. We have already reached the point where the control of function of public service is recognized as a prerogative of a government for and by the people; the next step is easy and logically inevitable, that in the complexity of modern industry the state in its broad sense should assume a responsibility for the daily safety of its citizens. We tread hourly over vault and boiler room where immense energies are under restraint; no individual can be a proper authority as to what is safe and acceptable in design or management for the protection of the innocent on his lawful occasions in street or public building, or even in his home apartment. Some states have already recognized the soundness of this principle in their legislation to secure safety at the tools and machinery of their factories; the contention of this discussion is to extend that sound principle so that it shall have an interstate application, so that a man shall be as safe near a farm boiler on the open highway as in the dense metropolitan areas and as safe in one state as he is in another.

My second and closing argument is based on the principle that a study of a law or a tendency near to the limits of its applicability will often reveal what is not obvious elsewhere. In the present case this means that no one would question the right or duty of a democratic form of government by the people to enter a community where the death rate from boiler or factory accidents and occupational disease exceeded the rate of growth of that community. The people of that village would be on the way to extermination and the settlement to extinction, and this seems to be in opposition to law divine as well as to human instinct. The legislative and executive arms of government would take hold with a strong hand to correct and remove the fatal conditions. If this is sound and defensible at the limit condition, is it less so or inapplicable in the normal or usual conditions, where there is a death rate from boiler and factory accident, but happily less than the maximum just imagined? It seems to me that the same law does apply. If it does apply, my point is made. The protection of life is a primary duty; in a popular form of government the representatives of the people are the responsible parties; such a body as is met here today may properly take initiative action.

If, then, it has been made clear that the facts and laws of applied science in respect to stresses and safety in pressure-resisting vessels have been codified and recorded, and a way pointed out whereby uniformity of standard in the various states of the Union may be secured, I shall feel that a large part of my privilege has been realized.

The afternoon session opened with an address from Hon. P. J. McBride, Commissioner of Labor of Kansas, on "The Protection of Labor as a Human Necessity and Its Effect on Business Economy." Mr. McBride emphasized the importance of greater attention to the safety of boilers and their appurtenances as an element in the industrial development of the nation.

Next Prof. L. P. Breckenridge, of Sheffield Scientific School, Yale University, spoke interestingly on "Civil Service in the Department of Boiler Inspection." He pointed out the importance of absolutely divorcing this department from politics, and showed how the civil service could best handle the examinations and appointments of the boiler inspectors. He referred to the A. S. M. E. Boiler Code as a set of boiler-construction rules that should be generally applicable in all states, and he made a plea for uniformity throughout. He produced statistics showing that in 1914 there were in the whole German Empire 8 boiler explosions—the same number that Mr. McBride had just admitted having in the State of Kansas in 10 months. In the United States in the same year there were 575 explosions; in Germany the loss of life was 2, in the United States 30; in Germany the personal injuries 7, in the United States 476.

S. F. Jeter, accredited representative of the State of Connecticut, read a letter from Governor Holcomb expressing his belief in the desirability of uniformity of laws covering similar commodities in different states and advising of his interest in the movement embraced in the Boiler Code Congress.

J. C. McCabe, chief inspector of the City of Detroit, Mich., spoke on "Realizations of a Uniform Boiler Code." He first showed clearly the hardship that is now imposed on both builders and purchasers of boilers by the numerous different codes and pointed out how necessary is this movement toward uniformity in construction codes. Mr. McCabe made a strong plea for a single uniform code, urged all states that have different codes to coöperate with the various states that have adopted, or are about to adopt, the A. S. M. E. Code, and announced that the State of Michigan would adopt that code this winter.

Mr. Callery announced that his state, which has in effect been working under two different boiler codes, is about to adopt the A. S. M. E. Boiler Code as its standard.

Hon. Victor T. Noonan, safety director of the Industrial Commission of Ohio, who was slated for an address on "Some Interesting Aspects of Accident Prevention" at the Tuesday morning session, was unable to be present and the time was occupied in general discussion. Thomas C. Eipper, deputy commissioner of the Department of Labor of the State of New York and connected with the Bureau of Industrial Code, said that the bureau had the A. S. M. E. Code under favorable consideration. The possibility of Federal supervision of boilers transported from one state to another was suggested. Henry Hess, chairman of the Standardization Committee of the A. S. M. E. and a member of the governing council of that society, read a paper telling of the genesis and history of the A. S. M. E. Boiler Code.

In the afternoon Hon. Edward N. Hurley, chairman of the Federal Trade Commission, read a paper on "Standardization as the Foreword of Business Efficiency." John A. Stevens, chairman of the Boiler-Code Committee of the A. S. M. E., told of the manner of production of the A. S. M. E. Code and the care which had been taken to have all interested parties have a voice in its formation.

The following resolution was unanimously adopted, only those having credentials from state or municipal executives being allowed to vote:

Whereas, Industry in every line of endeavor is very closely associated with steam as a motive power and the use of steam boilers; and

Whereas, Obtainable statistics covering a period of years show that in the United States there is annually a loss of from 400 to 500 lives and the disablement of from 1,000 to 3,000 people due to explosions of steam boilers; and

Whereas, The Government has recognized in the effort it has put forth in the safety movement that its first duty is the protection and safety of human life; and

Whereas, The Federal Government where it has the jurisdiction has prescribed rules for the construction of steam boilers; therefore, be it

Resolved, That it is the sense of this congress that all states should exercise supervision over the manufacture and use of steam boilers and all pressure vessels.

Mrs. Goldsmith read an address commending the work of the A. S. M. E. and urging the yielding of the more sedentary occupations to the women, while the men occupy themselves with the more active work of the world. William F. Kiesel, Jr., assistant mechanical engineer, Pennsylvania R.R., said that the railroads had interested themselves in the framing of the A. S. M. E. Code and were in favor of its adoption. Reports were heard from committees on legislation, boiler codes, interchangeability of inspectors, etc., and resolutions of thanks to the Ohio Industrial Commission and to Thomas E. Durban, chairman of the American Uniform Boiler Law Society, were adopted.

ENGINEERING AFFAIRS

The Buffalo Section of the A. S. M. E. will hold a meeting on Dec. 13. Russell Huff, president of the Society of Automobile Engineers and chief engineer of Dodge Bros., will speak on "A Plea for the Four-Cylinder Engine."

The Philadelphia Section of the A. S. M. E. will hold a joint meeting with the Franklin Institute of the State of Pennsylvania on Dec. 14. Carl C. Thomas, professor of mechanical engineering at Johns Hopkins University, will speak on "The Cooling of Water for Power-Plant Purposes."

Proposed Construction

Ala., Canton—Town granted Alabama Power Co. franchise to install electric-light plant.

B. C., Trail—Consolidated Mining and Smelting Company of Canada plans improving lighting and power systems. About $25,000 or $30,000.

Calif., Los Angeles—Sespe Light and Power Co., Los Angeles, making plans for hydro-electric plant on Ventura River. R. Bennett, Central Building, Los Angeles, engineer.

Conn., Devon—(Milford post office)—United Light and Water Co., Waterbury, plans power plant at Devon. About $1,000,000.

D. C., Washington—(Official)—Bureau of Supplies and Accounts, Navy Department, Washington, soon to receive bids for 1,536 gage glasses, under Schedule No. 480, for Philadelphia and Norfolk Navy Yards.

D. C., Washington—(Official)—Bureau of Supplies and Accounts, Navy Department, Washington, soon to receive bids for 82,500 ft. of air rubber hose, under Schedule No. 477, for Norfolk and Brooklyn Navy Yards.

Fla., New Smyrna—City plans street-lighting system.

Ga., Greensboro—City plans electric-light plant.

Iowa, Bloomfield—City plans improving electric-light plant. About $25,000.

Iowa, Delhi—Board of Railroad Commissioners of Iowa granted franchise to Iowa Electric Co. to build electric transmission line from Delhi to Oneida and Worthington.

Iowa, Webster City—City plans improving electric-light and water plants.

Minn., New Ulm—City plans extending electric-lighting system.

Minn., Virginia—Great Northern Power Co. plans addition to plant and 66,000-volt transmission line from Thomson to Virginia.

Mo., Kirkwood—City plans improving electric-light plant. About $8,000.

Neb., Oconto—Local business men plan organizing company to install electric-light plant.

N. J., Newton—Newton Electric and Gas Co., recently incorporated with $500,000 capital stock, applied to Board of Public Utility Commisioners for permission to issue bonds to extend and improve plant.

N. Y., New York—(Brooklyn)—(Official)—Bureau of Supplies and Accounts, Navy Department, Washington, D. C., soon to receive bids for 10,000 ft. of light and power wire and 90,000 ft. of telephone wire, under Schedule No. 474; 16,000 terminals for connecting boxes, wire magnet, single and double conductor wire and twin conductor wire, under Schedule No. 475.

N. Y., New York—(Brooklyn)—(Official)—Bureau of Supplies and Accounts, Navy Department, Washington, D. C., soon to receive bids for 360 push buttons, under Schedule No. 475, for Brooklyn Navy Yard.

N. Y., Rossie—City plans electric-light and power plant.

Ohio, Elyria—Elyria Memorial Hospital receiving bids Dec. 15 for one-story power plant. About $5,000. P. Rissman, Elyria Building, architect.

Ohio, Oxford—City voted $10,000 bonds to rebuild and extend electric plant.

Okla., Mounds—City plans electric-light plant.

Okla., Lindsay—City voted $6,000 bonds to improve municipal electric-light plant.

Okla., Morrison—City soon to vote on $7,000 bonds for installing electric-lighting system.

Ont., Hawkesbury—Riordon Pulp and Paper Co. plans addition to boiler house in Hawkesbury, Ont., not in Hawkesbury, Vt., as noted in our issue of Nov. 28.

Penn., Philadelphia—(Official)—Bureau of Supplies and Accounts, Navy Department, Washington, D. C., receiving bids Dec. 19 for 38 steam traps, under Schedule No. 479, for Navy Yard, Philadelphia.

Que., Lake Megantic—Lake Megantic Electric Co. will rebuild plant recently destroyed by fire.